SL Paper 3

a. State **two** functions of proteins, giving a **named** example of each. [2]

b. Explain the significance of polar and non-polar amino acids. [3]

Markscheme

a. enzymes/biological catalyst – amylase/protease/lipase/catalase;

defence/immunity – immunoglobin/antibody;

structure – collagen;

movement – actin/myosin;

transport – hemoglobin;

synthesis – ligase/DNA polymerase;

hormonal communication – insulin/luteinizing hormone; *MUST be proteinaceous*

food stores – casein in milk;

pigments – opsin;

Accept any other valid responses.

b. polar amino acids have hydrophilic R groups, non-polar have hydrophobic R groups;

non-polar amino acids in centre of water-soluble proteins stabilise their structure;

non-polar amino acids cause proteins to remain embedded in membrane;

polar amino acids on surface of proteins make them water-soluble;

polar amino acids create hydrophilic channels/protein pores in membranes;

enzyme active site specificity depends on amino acids present/polar and nonpolar amino acids can play a role in substrate interactions at the active site;

Examiners report

a. This was answered well by the majority of candidates, and they could give suitable named examples.

b. Many candidates gave vague responses, and many appeared to not understand the concept of hydrophilic and hydrophobic. Few could discuss the roles of the amino acids in proteins.

a. State the names and functions of the antagonistic muscles of the human elbow joint. [2]

c. Explain the role of ATP in muscle contraction. [2]

Markscheme

a. a. biceps flexes/bends the arm;

b. triceps extends/straightens the arm;

c. a. ATP binds to myosin heads;

b. ATP used to break cross bridges;

c. energy released when ATP forms ADP and phosphate;

d. myosin head reset;

e. actin slides over myosin;

Examiners report

a. Most candidates knew the functions of the biceps and triceps muscles.

c. There was much confusion over the exact role of ATP in muscle contraction.

Outline the variation in the structure of fatty acids.

Markscheme

cis (isomers) <u>or</u> trans (isomers);

saturated <u>or</u> unsaturated;

monounsaturated <u>or</u> polyunsaturated;

location of the double bond;

can be short chain <u>or</u> long chain;

Examiners report

Most candidates scored full marks on this question.

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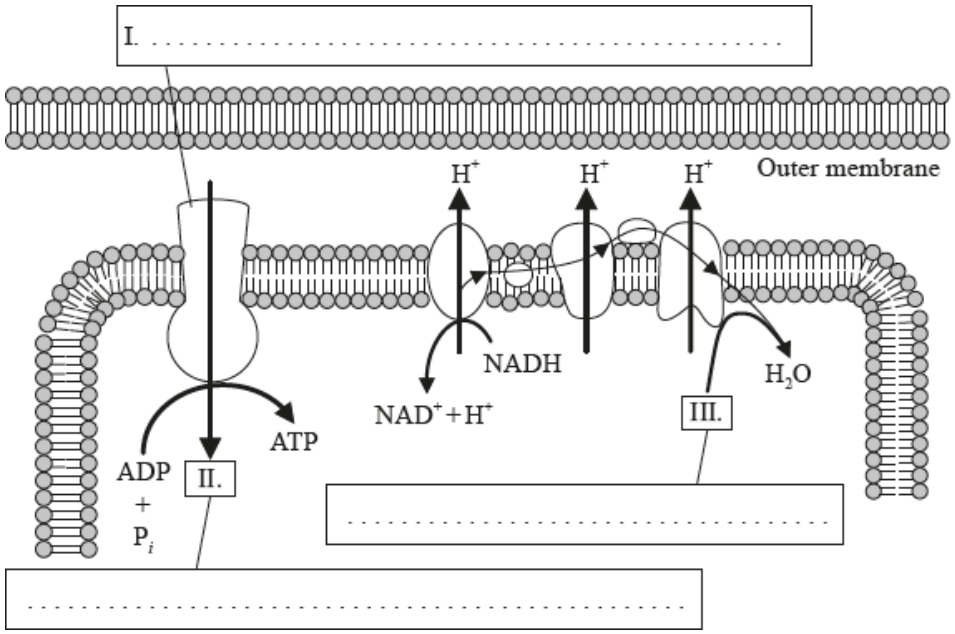
a.i. Other than acting as catalysts state **three** functions of proteins, giving an example of each. [3]

b. The diagram shows chemiosmosis in the mitochondrion. Label I, II and III. [3]



[Source: © International Baccalaureate Organization 2014]

Markscheme

a.i. structural – collagen / membrane proteins;

transport – hemoglobin / protein channels;

movement – actin / myosin;

hormones – insulin / vasopressin / growth hormone;

defense – antibodies / immunoglobins;

Award any other valid function and example.

b. I. ATPsynthase; (*accept ATPsynthetase*)

II. H^+ / protons;

III. O_2/oxygen;

Examiners report

a.i. This was an easy question on proteins with most candidates getting full marks for both (i) and (ii)

b. This question was very discriminating as only a few got this correct; it appeared that candidates either scored all 3 marks for correctly labelling what was happening in chemiosmosis, or none. There were some comments on the G2 forms that this diagram was a little unclear. It was felt that this was a very clear diagram, however, it was a bit tricky to decide what substances the arrows were referring to. The use of the word 'molecules' in the stem seemed to have confused some as label II was for protons (H^+).

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a. Outline primary and quaternary protein structures. [2]

Primary protein structure:

Quaternary protein structure:

b. List **three** limiting factors of photosynthesis. [3]

Markscheme

a. a. (primary structure) is sequence of amino acids;

b. (quaternary structure) is the linking of two or more polypeptides to form one protein;

b. a. temperature;

b. pH;

c. light;

d. CO_2;

Examiners report

a. Only the better candidates could give a satisfactory outline of both the primary and secondary structure of protein.

b. N/A

---

a. List **three** functions of proteins, giving a **named** example of each. [3]

b. Explain the significance of polar amino acids and non-polar amino acids in membranes. [2]

Markscheme

a. catalysts/digestion – amylase/protease/lipase/catalase;

defense – immunoglobin / fibrinogen;

structure – collagen;

movement – actin/myosin;

transport – hemoglobin;

synthesis – ligase/DNA polymerase;

hormonal communication – insulin/luteinizing hormone;

light detection – rhodopsin / plant phytochromes;

storage – ferritin/gluten/casein;

Accept any other valid responses.

b. non-polar amino acids for hydrophobic part of the bilipid layer;

polar amino acids for hydrophilic environment;

polar amino acids allow hydrophilic channels;

integral proteins are held in place by polar amino acids;

*To award **[2 max]** both polar and non-polar should be addressed.*

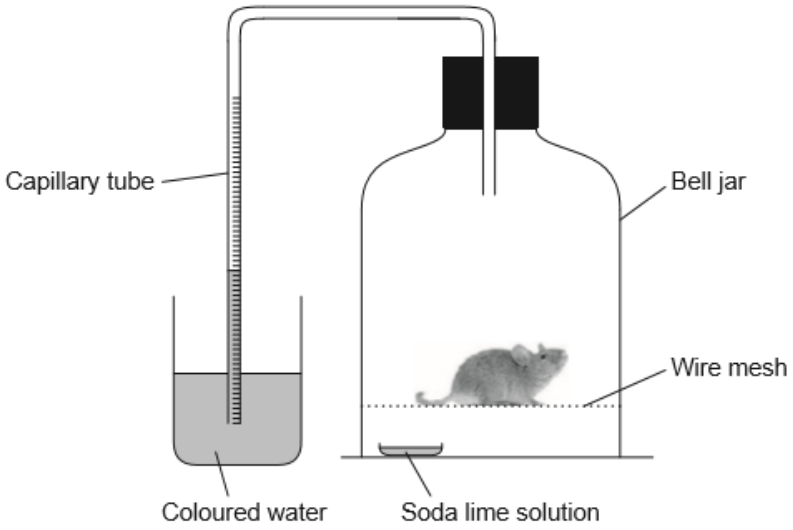
Accept answers in the form of a diagram.

Examiners report

a. Here some candidates did not read the entire question and only listed the functions without a named example.

b. C3 (b) seemed to be very difficult and very few got this question right. Some candidates did mention the polarity and hydrophobicity of the amino acids, but did not mention the significance of them to membranes. This is clearly an area that needs reinforcing.

In an experiment measuring oxygen consumption, a laboratory mouse was placed in a respirometer for a short time. Soda lime solution absorbed any carbon dioxide produced during the experiment.



[Source: © International Baccalaureate Organization 2016]

a. Suggest the purpose of the wire mesh. [1]

b. Describe how the apparatus measures the oxygen consumption of the mouse [3]

c. Discuss whether the apparatus would be suitable for measuring the oxygen consumption of a small green plant during respiration. [3]

Markscheme

a. a. allow gases to pass between mouse and soda lime

b. prevent mouse getting in contact with soda lime

c. prevent mouse from being in contact with faeces/urine/droppings

b. a. more oxygen in inhaled air than in exhaled air

OR

mouse uses oxygen in respiration

b.carbon dioxide exhaled / produced by mouse is absorbed by the soda lime

Source/mouse must be mentioned for marking point b – not just “soda-lime absorbs $C0_2$”.

c. difference in volume is oxygen used by mouse
OR
the volume/concentration/pressure of oxygen in the jar falls

d. «this» sucks the coloured liquid up the tube

e. volume of oxygen consumed equals the increase in volume of coloured water in the tube

c. a. oxygen released during photosynthesis

b. plants use carbon dioxide (released by respiration)

c. if carbon dioxide is too low in concentration then photosynthesis will be eliminated/reduced

d. results in an inaccurate/low measure of the oxygen that is consumed

e. perform experiment in dark to prevent photosynthesis
OR
cover bell jar to exclude light to prevent photosynthesis

Do not accept plants convert carbon dioxide to oxygen.

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

---

a. State the location of high proton concentration caused by electron transport in the mitochondrion. [1]

b. Outline the role of oxygen in cellular respiration. [2]

c. Explain how any **two** structural features of the mitochondrion are related to its function. [2]

Markscheme

a. inter-membrane space / outside inner membrane / between outer and inner membrane

b. in the electron transport chain;

final electron/hydrogen acceptor;

combines with H^+ (and electrons) to produce water;

c. cristae for increasing surface area;

small inter-membrane space for rapid build-up of concentration gradient;

matrix with chemical concentration to support unique chemical reactions;

Examiners report

a. Most candidates answered this question correctly.

b. Candidates failed to understand the role of oxygen in respiration. They explained how oxygen is necessary for aerobic respiration, but did not understand why.

c. The presence of cristae to increase surface area was among the most common correct answers regarding the features of mitochondria relating to their structure. Other features were hardly mentioned.

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a. Transport is the function of the protein known as hemoglobin. State the name and function of another protein. Do not use enzymes or membrane proteins for your answer. [1]

Name: .....
Function: .....

b. Explain the role of enzymes in metabolic pathways. [4]

c. Describe how the link reaction and the Krebs cycle are related. [2]

Markscheme

a. name of protein;

function of protein;

(*both needed*)

b. a. enzymes speed up/catalyse metabolic reactions;

b. by reducing the activation energy;

c. each reaction (in the pathway) has a different enzyme;

d. metabolic pathways can be controlled by controlling which enzymes are produced;

e. end-products of a metabolic pathway act as inhibitors;

f. end-product inhibitors bind to/inhibit an enzyme at the start of the pathway;

c. a. the link reaction produces acetyl CoA/acetyl group/CH_3CO;

b. acetyl group/CH_3CO joins with 4 carbon compound/OAA from cycle;

c. both occur in the (mitochondrial) matrix;

Examiners report

a. In (a) naming a protein and its use should have been an easy mark. Unfortunately it was very poorly answered.

b. In b most knew the function of enzymes and their reduction of the activation energy. However, only the better candidates gained the other marks by correctly putting them into the context of pathways.

c. In c the production of Acetyl CoA from the link reaction was well understood. Unfortunately its destiny was less well known.

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a. Outline the molecular structure of different types of fatty acids. [3]

b. Evaluate the benefit of reducing cholesterol in the diet. [3]

Markscheme

a. fatty acids share a common structure but differ in the total number of carbon atoms in the chain;

saturated fatty acids have no double bonds between carbon atoms;

unsaturated have double bond(s);

monounsaturated have one double bond / polyunsaturated have more than one double bond;

cis fatty acids have adjacent hydrogen atoms on same side of double bond and *trans* have them on opposite side;

(accept annotated diagrams)

b. cholesterol is a steroid found mainly in animal products;

it builds up in the walls of arteries / causes clogging/narrowing/blockage of artery / atherosclerosis;

lowering its ingestion may lower the probability/ risk of coronary heart disease/CHD;

cholesterol can be synthesized by the liver;

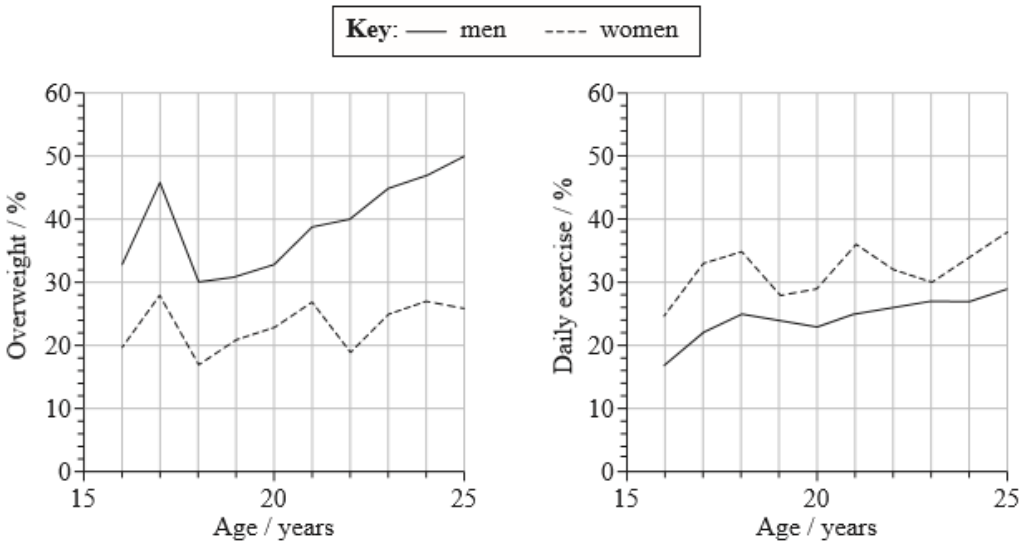
factors other than diet can affect levels of cholesterol / genetic factor more important than diet;

Examiners report

a. Although candidates did not note that fatty acids share a common structure but differ in the total number of carbon atoms in the chain, many were still able to get the full 3 marks for this question. Candidates showed a good understanding of saturated and unsaturated fatty acids as well as what cis and trans referred to. Some candidates were carelessly referring to hydrogen bonds and thus losing marks.

b. Many candidates received 2 but seldom 3 marks for evaluating the benefit of reducing cholesterol in the diet. Most did not seem aware that cholesterol can be synthesized by the liver or that factors other than diet can affect levels of cholesterol.

Within a cross-sectional study “Fit for Life” in Germany, the body mass index (BMI) of volunteers aged between 16 and 25 years was investigated. Volunteers were also interviewed about their daily exercise habits. The graphs below show the percentage of men and women who were overweight, and the percentage who exercised daily.



[Source: adapted from D Leyk, *et al.*, (2008), *Deutsches Ärzteblatt International*, **105**(46), pages 793–800]

a. Measure the difference between the percentage of overweight men and the percentage of overweight women at age 20. [1]

b. State the range of the body mass index (BMI) that corresponds to overweight status. [1]

c. Compare the percentage of men and women who exercised daily. [2]

d. Evaluate the hypothesis that being overweight is due to lack of exercise. [3]

Markscheme

a. 10 (%) (*allow responses in the range of 9 to 11 %*)

b. 25.0 –29.9 / above 25 and below 30

Do not accept 30 as this is classed as obese.

c. more women exercise than men;

both show an increase (between ages 16 to 25);

similar trend lines over time / slightly greater increase in women;

women have greater increases and decreases/greater variability while men gradually increase/stays level;

Award any one of the above marking points if shown as a valid numerical comparison.

d. *(*hypothesis is supported) as the greater percentage of men are overweight and they exercise less than women / *vice versa*;

(hypothesis is supported) lowest percentages of overweight ages (18 and 20) correspond with peaks of exercise;

(hypothesis is not supported) as even though both men and women exercise more over time the percentage overweight also increases;

(hypothesis is not supported) other named factor which influences being overweight; (*e.g. availability of cheap high energy foods* / *large portion sizes* / *increasing use of vehicles for transport* / *changes from active to sedentary occupations* / *genetics*)

BMI does not consider muscle mass/bone structure/bone density;
only narrow range of ages considered;

Examiners report

a. Almost all candidates read the graphs correctly to obtain the correct difference between overweight men and women.

b. Many did not give the correct range for the BMI corresponding to overweight status, giving incorrect upper limits.

c. Many candidates were able to get one mark for indicating that more women exercise than men but only some were able to get a second mark.

d. Candidates struggled with this question, primarily as they did not use the data to evaluate the hypothesis given. Instead of looking at how the data either supports or does not support the hypothesis, they talked in general about factors that could influence being overweight. One comment on the G2 forms indicated that it was hard to find 3 points for an answer to this when in fact the mark scheme provided 6 ways of getting the points.

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b. Outline factors that can lead to an individual becoming obese. [3]

c. Amino acid polarity is an important factor in determining the functions of proteins. Explain the importance of polar and non-polar amino acids in membrane proteins. [3]

Markscheme

b. diet rich in carbohydrate/fat;

too much food intake / unbalanced diet / food cheap and readily available;

sedentary lifestyle / lack of training/exercise;

genetic disposition/disorder;

malfunction of hunger centre;

c. polar amino acids are soluble/have stable interactions in water/extracellular fluid/cytoplasm;

non-polar amino acids are soluble/have stable interactions in the lipid bilayer;

polar amino acids strongly hydrophilic and non-polar amino acids are repelled by water/are hydrophobic;

(help to) retain protein in position in the membrane;

polar amino acids form hydrophilic channels/protein pores in membranes;

transmembrane proteins have polar amino acids on either side of the membrane;

Examiners report

b. There were some good answers by the majority of students, with many gaining three marks. Interestingly, few suggested a malfunction of the hunger centre, which was an acceptable alternative.

c. The understanding of many candidates was insufficient to answer this question, and it proved to be a good discriminator. Often students were writing about proteins rather than amino acids.

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a. List **two** possible variants in the molecular structure of unsaturated fatty acids. [2]

b. State **one** reason to include fibre in the diet. [1]

c. Describe the health consequences of a diet rich in proteins. [3]

Markscheme

a. number of carbons (in the chain/length of chain);

number of double bonds (in the chain) / may be monounsaturated/ polyunsaturated;

cis/trans structure in unsaturated fatty acids / *OWTTE*;

location of double bonds;

counting inwards from opposite end of COOH group/omega 3/omega 7;

b. (bulk) may help regulate digestive process/peristalsis/prevent constipation;

may lower risk of *colon/intestinal* cancer/appendicitis/diabetes/cardiovascular disease;

may decrease hunger (helping with control of food intake);

c. quick drop in weight (through loss of body fluids);

important for children/pregnant/breastfeeding women;

loss of calcium ions in urine / possible risk of osteoporosis;

unbalanced diet / lack of essential nutrients;

e.g. essential vitamins/minerals/fibre;

possible rise in blood pressure;

release of ketones into bloodstream/ketosis (causing loss of appetite);

possible risk of kidney/liver disorders/stones/reduced functioning;

gout;

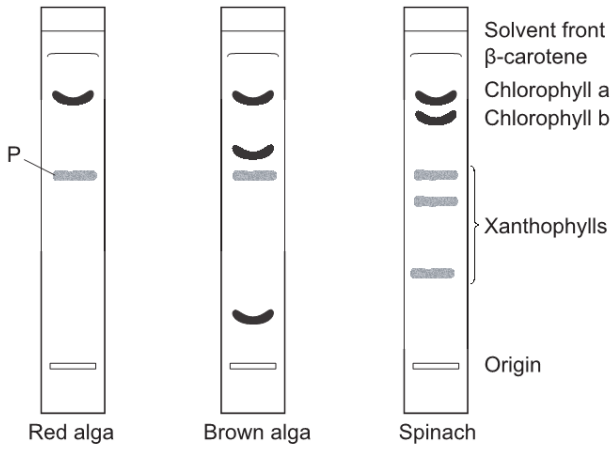
Examiners report

a. A2 (a) was well answered by most. Most candidates mentioned monounsaturated and polyunsaturated and some cis and trans.

b. The majority of candidates explained the importance of fibre in the diet with in-depth explanation, although some candidates gave answers without biological jargon, such as "fibres clean the guts".

c. Many candidates gave very long answers talking about the dangers of the fats associated to proteins (for example in beef) but did not make reference to the dangers of a protein-rich diet.

Thin-layer chromatography was carried out on red and brown algae to discover what photosynthetic pigments they contained. The results were compared with the known pigments found in spinach leaves.



a. Identify pigment labelled P. [1]

b. State a suitable solvent for extracting photosynthetic pigments from plant tissue. [1]

c. Explain how the pigments in the chromatogram of spinach are identified. [3]

Markscheme

a. xanthophyll

b. acetone

OR

alcohol

OR

ether

Accept other named organic solvent

If there is more than one answer accept only the first one. (Note: “Water mixed with alcohol” would be correct as would “alcohol, water” but “water, alcohol” would be incorrect)

c. a. they can be identified by their colour/analysis with spectrometer

b. measure the distance travelled by the solvent front

c. measure the distance travelled by the pigment

d. calculate the R_f value

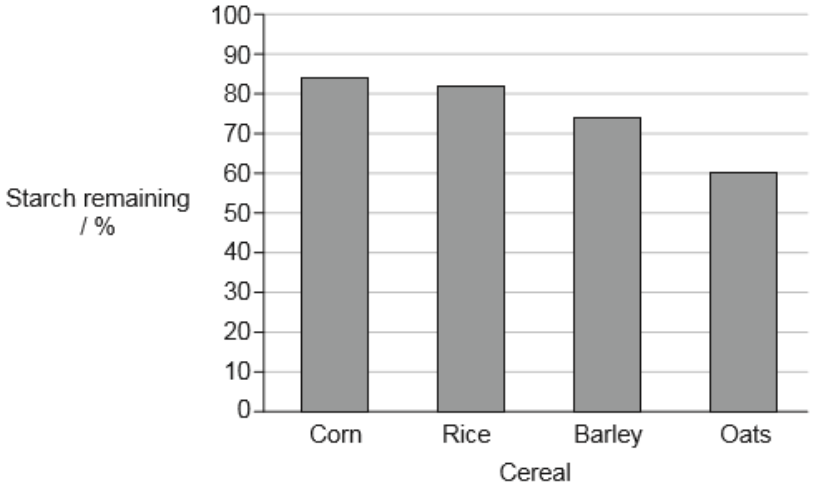
e. they can be identified by comparing R_f values to known values

[Max 3 Marks]

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

The enzyme amylase was extracted from the digestive system of horses and added to whole cereal grains (seeds) in test tubes at 39°C to determine which grain was digested quickest. Each test tube received equal quantities of the enzyme. The quantity of starch remaining in the grains after 15 minutes was measured.



[Source: adapted from N Richards, *Enhancing Starch Digestion in the Equine Small Intestine*. Doctoral thesis, University of New England, http://e-publications.une.edu.au/1959.11/15182. Copyright 2003 - Nerida Richards]

a. Suggest **one** reason for differences between the cereal grains, in the percentage of starch remaining after 15 minutes. [1]

b. Suggest **one** method that could have been used to keep the tubes at a constant temperature. [1]

c. Explain the importance of having equal quantities of the enzyme at the start of the experiment. [2]

Markscheme

a. a. different types/amounts of starch

b. grains are different sizes/numbers
OR
time taken for amylase to penetrate differs between grains
OR

seed coat thickness varies
OR
different surface area to volume ratio

b. placed in the same waterbath

OR

use metal hot-blocks

Allow any viable suggestions.

Do not accept refrigeration (as enzyme need warmer temperatures)

Do not accept monitored by a thermometer as this does not keep constant temperature.

Do not accept "keep in a temperature controlled environment" as too vague.

c. a. there should only be one variable in the experiment

OR

the only difference between the tubes should be the type of grain

OR

experiment should be fair/reliable/consistent

b. experiments should have a control

c. less enzyme may make the reaction go slower
OR
more enzyme may make the reaction go faster
OR
changing the amount of enzyme could affect the rate of reaction

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

Urease is an enzyme that breaks down urea into ammonia and carbon dioxide. The ammonia produced causes the pH of the solution to rise. This

reaction can be followed using a pH indicator or a pH probe.

In an experiment conducted by a student the time taken for the pH indicator, thymol blue, to change from yellow to blue was recorded at different temperatures.

Temperature / °C ± 1	Time / s ± 1						
	Trials					Mean	Standard deviation
	1	2	3	4	5		
30	109	62	79	59	65	75	21
40	54	46	38	42	43	45	6
50	31	30	31	34	27	31	3
60	23	18	19	21	18	20	2
70	19	29	29	31	36	29	6

[Source: © International Baccalaureate Organization 2017]

a. Outline what the standard deviations reveal about the data from this experiment. [2]

b. One result in this experiment can be classified as an outlier as its value is very distant from those of the other values. [2]

Explain an appropriate procedure for dealing with outliers.

c. Outline the effect of temperature on the activity of urease enzyme. [2]

d. State **one** factor that would need to be controlled in this experiment. [1]

Markscheme

a. a. standard deviation indicates the degree of variation in the data

OR

the spread of data around the mean

b. high standard deviation at 30°C «in proportion to the average» indicates less reliable data

c. low standard deviation for results from 40 to 70°C indicates more reliable data

b. a. outliers should not be deleted from the data set

OR

trend lines may ignore outliers>

OR

use a z-score/test

b. could be incorrectly entered or measured data

c. repeat experiment/reading/trial «for that point»

c. a. the reaction / activity increases with temperature

b. rate slows from 60°C to 70°C

c. fastest increase in activity is between 30°C - 40°C

d. optimum temperature is 60°C

d. a. concentration / volume of urea «solution»

b. concentration / volume of urease «solution»

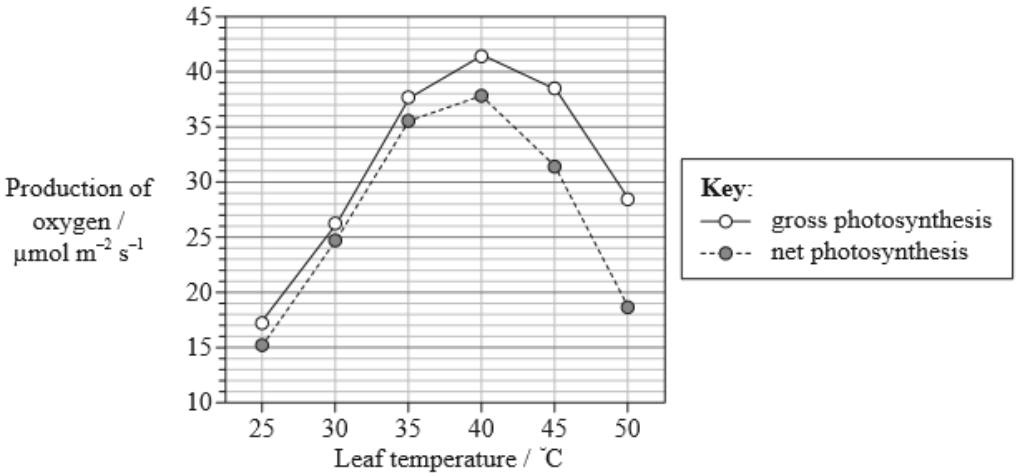
c. concentration / volume of indicator

d. lighting conditions / background «to test tubes»

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]
d. [N/A]

The effect of temperature on photosynthesis was studied in sweet orange (*Citrus sinensis*) using leaf discs. The production of oxygen was used to measure the rate of photosynthesis. Gross photosynthesis refers to the sum of net photosynthesis and respiration. Net photosynthesis was calculated by subtracting the rate of respiration in the dark from gross photosynthesis.



[Source: adapted from R Ribeiro, *et al.*, (2006), *Ciência e Agrotecnologia*, **30**, pages 670–678]

a. Identify the optimum temperature for photosynthesis in this plant. [1]

b. Determine the difference between gross photosynthesis and net photosynthesis at 40°C and 50°C. [2]

40 °C: .....

50 °C: .....

c. Deduce what happens to the rate of respiration as the temperature increases between 40°C and 50°C. [1]

d (i) Describe the general pattern of change in photosynthesis in sweet orange as the temperature increases. [1]

d (ii) Compare the effect of temperature on photosynthesis with the effect of temperature on respiration in sweet orange. [2]

Markscheme

a. 40°C

b. 40° C : 3.5 μmol m^{-2} s^{-1}; (*units required*)

Accept answers between 3.0 μmol m^{-2} s^{-1} and 4.0 μmol m^{-2} s^{-1}.

50° C : 10 μmol m^{-2} s^{-1}; (*units required*)

Accept answers between 9 μmol m^{-2} s^{-1} and 11 μmol m^{-2} s^{-1}.

c. rate of respiration is increasing

d (i) rate increases as the temperature increases up to a point/40°C and then decreases

d (ii) at low temperatures/between 25°C and 35°C the rate of photosynthesis increases and the rate of respiration is (approximately) constant;

between 35°C and 40°C both increase;

as temperature continues to increase the rate of photosynthesis reaches optimum whereas rate of respiration decreases less/stays constant/increases;

at high temperatures/between 40°C and 50°C photosynthesis decreases as respiration decreases less/stays constant/increases;

Examiners report

a. C1 was well answered by most candidates.

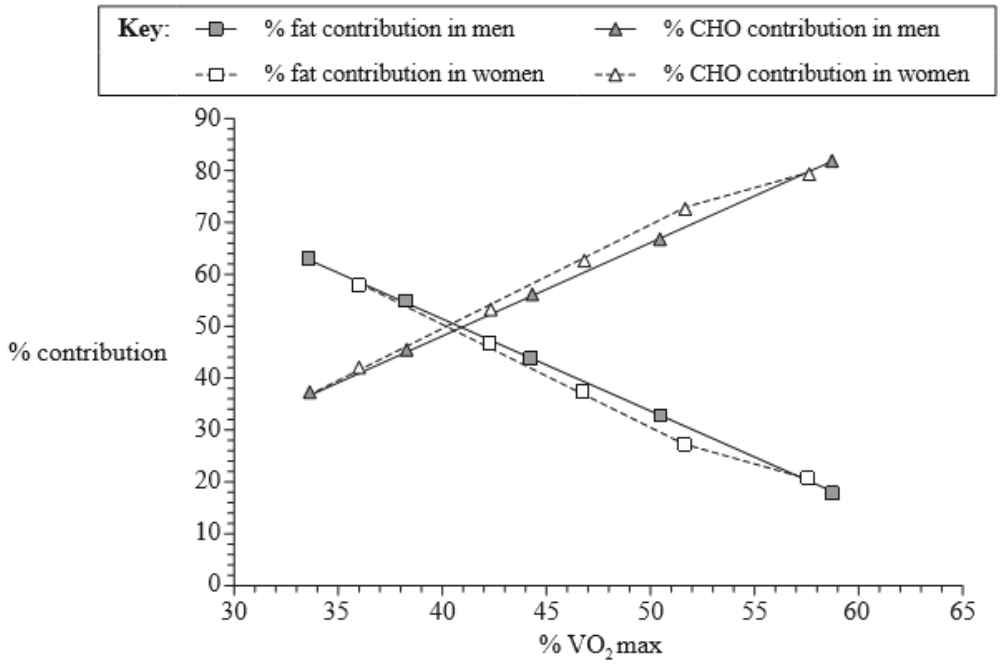
b. C1 was well answered by most candidates.

c. C1 was well answered by most candidates.

d (i) C1 was well answered by most candidates.

d (ii) C1 was well answered by most candidates.

A treadmill test was taken by 46 men and women who were inactive and overweight. During the test, the percentage of fat and carbohydrate (CHO) used for energy was measured at increasing levels of exercise intensity. The intensity of exercise was assessed by measuring VO_2 and showing it as a percentage of VO_2 max.



Reprinted from *JSSM*, 7, Bogdanis, Vangelakoudi and Maridaki "Peak fat oxidation rate during walking in sedentary overweight men and women." pp. 525–531. Copyright (2008), Figure 3. With permission from the JOURNAL OF SPORTS SCIENCE AND MEDICINE.

b. State the percentage contribution of the different sources of energy at 36% VO_2 max in women. [1]

Fat: .....
CHO: .....

c. Using the data in the graph, describe the relationship between the intensity of exercise and the source of energy. [3]

d. Fat can only be used in aerobic respiration. Suggest reasons for the change in the percentage contribution of fats to energy supply during exercise as the intensity of exercise increases. [2]

Markscheme

b. fat: 58 (%); (*allow responses in the range of 57 to 59 %*)

CHO: 42 (%); (*allow responses in the range of 41 to 43 %*)

(*both needed*)

c. fat contributes most energy/63 (±1)% at lower level of exercise intensity;

contribution of fat as an energy source decreases as exercise intensity increases / negative correlation;

contribution of CHO as an energy source increases as exercise intensity increases / positive correlation;

fats and carbohydrates used equally / crossover point is 41 % VO_2 max;

little difference between men and women;

d. at lower exercise intensity (more) oxygen available for aerobic respiration;

(stored) fat will supply energy when oxygen is available;

as exercise intensity increases anaerobic respiration increases;

less oxygen available (in anaerobic respiration) means more CHO metabolism/ less fat metabolism (at higher exercise intensity);

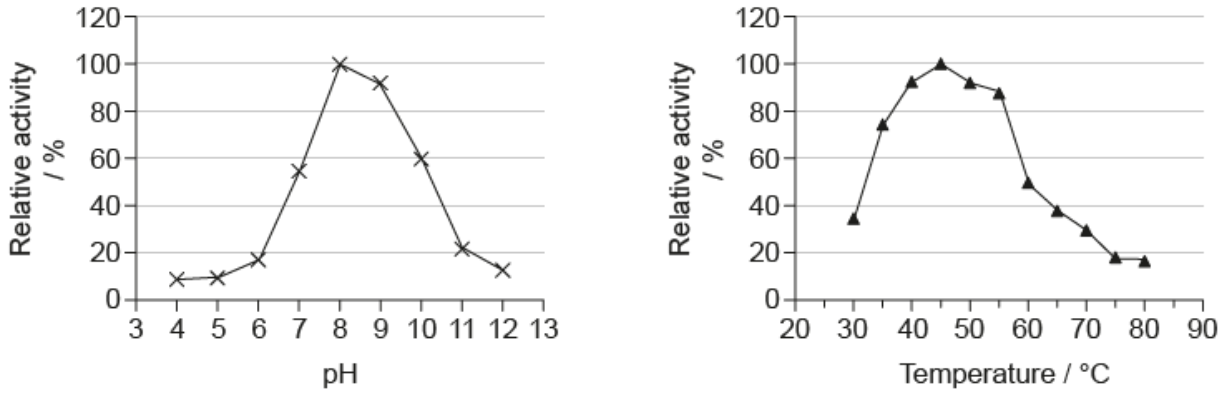
Examiners report

b. Almost all candidates were able to get the mark for reading the correct values from the graph.

c. Many candidates found it difficult to use the data to describe the relationship between intensity of exercise and source of energy. Better candidates were able to score two or three marks.

d. Most candidates struggled with this section and did not relate their answers to oxygen availability for aerobic and anaerobic exercise.

Keratin is a protein found in hair, nails, wool, horns and feathers. The graphs show the relative keratinase activity obtained in experiments into keratin digestion at different pH values and different temperatures.



[Source: Kim Jeong-Dong (2007) 'Purification and Characterization of a Keratinase from a Feather-Degrading Fungus, *Aspergillus flavus* Strain K-03.' *Mycobiology*, 35(4), pages 219–225]

a. Determine the optimum pH and temperature of keratinase. [1]

b. Suggest **two** changes occurring in the reaction vessel that could be used to indicate keratinase activity. [2]

c. State **two** conditions that should be kept constant in both experiments. [2]

Markscheme

a. pH=8 ***AND*** temperature=46 °C

Both needed.
Accept answers in the range of 7.8 to 8.5 pH and 44 to 48 °C .
Units required.

b. a. the amount of keratin measured *OWTTE*

OR

decrease in keratin mass

OR

size of keratin containing object

b. the increase in peptides/amino acids/product

c. changes in colour/absorbance/smell

c. a. amount/concentration of enzyme

b. amount/concentration of keratin/substrate

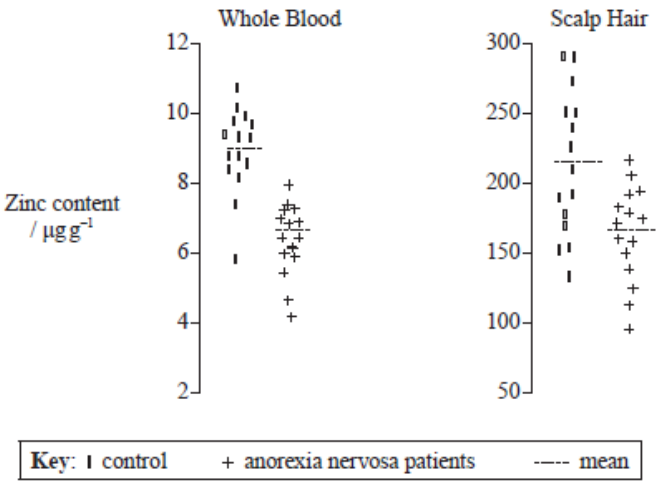
c. amount of buffer

d. time/duration of experiment

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

Zinc (Zn) is an important dietary nutrient. More than 200 enzymes that are dependent on zinc have been identified. One consequence of zinc deficiency is suppression of appetite, due to reduced sensitivity to tastes and smells. A recent study compared the presence of zinc in tissue and fluid samples collected from 15 patients with anorexia nervosa to that from 15 control patients. The results are shown in the graphs below.



[Source: adapted from TE Tuormaa, (1995), *Journal of Orthomolecular Medicine*, **10**, pages 149–164]

a. Compare the zinc content of scalp hair of the control group with that of the anorexia nervosa group. [2]

b. Discuss whether whole blood zinc content of 6 μg g^{-1} would indicate that a person has anorexia nervosa. [2]

c. Discuss whether dietary zinc supplementation would be an effective treatment for anorexia nervosa. [2]

d. Zinc is a mineral. Distinguish between a mineral and a vitamin. [1]

e. State the body mass index (BMI) below which a person is considered to be underweight. [1]

Markscheme

a. mean zinc content higher in control group;

control group more variable;

overlap between two groups / highest of anorexia nervosa group equals mean of control group;

b. (data suggest this is) probable / could be symptom;

other conditions could lead to low zinc;

6 μg g^{-1} is within the lower range of "normal";

c. zinc supplementation is necessary for insufficient dietary intake / improvement in below normal intake would be resolved;

improved appetite may result;

low zinc may be effect not cause of anorexia nervosa / other causes of anorexia;

d. minerals are inorganic while vitamins are organic;

minerals tend to be in ionic elemental form/small molecules while vitamins tend to be larger molecules;

e. (below a BMI of) 18.5kg m^{-2} *(units needed)*

Examiners report

a. Many candidates answered the comparison well, but many others simply stated numbers instead of comparing.

b. This question was generally answered well. Many candidates realised that this value could be an indicator of anorexia because it was very low, but there was a control person who had this same value.

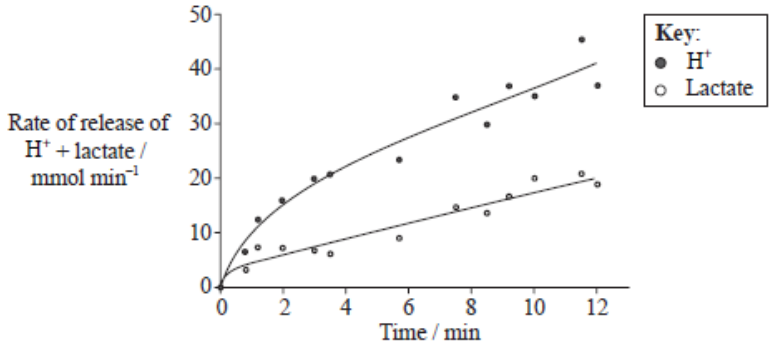
c. Generally answered well.

d. Many candidates failed to answer this question correctly.

e. Many candidates failed to give the units for BMI.

A build-up of hydrogen ions (H^+) in muscles causes a condition known as acidosis. Anaerobic cell respiration of glucose in the muscles leads to the production of lactate and H^+. One molecule of glucose is converted into two lactate ions and two H^+ (a 1:1 ratio of lactate to H^+).

The development of acidosis during intense exercise has traditionally been explained by the increased production of lactate and H^+ from the breakdown of glucose. This hypothesis has led to the interpretation that anaerobic cell respiration causes acidosis which leads to muscle fatigue during intense exercise. The graph below shows the quantities of H^+ and lactate released from contracting muscles during vigorous exercise.



[Source: Figure 6 , Carsten Juel, Christina Klarskov, Jens Jung Nielsen, Peter Krustrup, Magni Mohr, Jens Bangsbo. "Effect of high-intensity intermittent training on lactate and H+ release from human skeletal muscle." *American Journal of Physiology Endocrinology and Metabolism* 286: E245-E251, 2004. First published October 14, 2003; 10.1152/ajpendo.00303.2003. Used with permission.]

a. Compare the rate of release of lactate with the rate of release of H^+ in contracting muscles during vigorous exercise. [2]

b. Evaluate the hypothesis that acidosis in muscles is due entirely to H^+ production as a result of anaerobic glucose breakdown. [2]

c. Predict the results if the data had been collected beyond 12 minutes. [2]

Markscheme

a. both rates increase with time;

rate of release of H^+ always higher;

rate of release of H^+ increases faster than that of lactate;

b. lactate production indicates anaerobic cell respiration;

a correlation between lactate and H^+ / some support for hypothesis;

expect 1 H^+ to 1 lactate / ratio of H^+ to lactate higher than 1:1;

H^+ cannot account for all the acid / there must be another source of H^+;

c. both will continue to rise;

because of the acid, they cannot both continue to rise indefinitely / will level off;

because of muscle fatigue, they cannot both continue to rise indefinitely / will level-off;

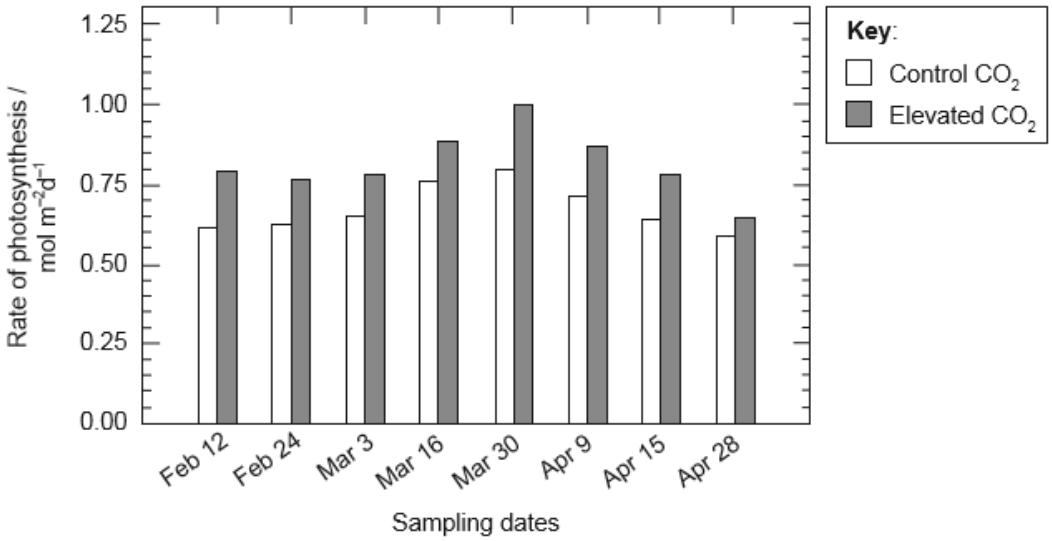
Examiners report

a. Usually answered well.

b. Few candidates got the two marks. Few realized there must be another source of H^+.

c. Many candidates failed to realise that the graph will level off due to muscle fatigue.

In a study carried out at the University of Arizona, the effects of increased CO_2 concentration on the rate of photosynthesis in spring wheat, *Triticum aestivum*, were investigated over the course of an entire growing season (from the beginning of February to the end of April). The rate of photosynthesis was measured as the rate of CO_2 uptake from the time of emergence from the seed to maturity. The control plants were grown at a normal air CO_2 concentration while the test plants were grown at an elevated CO_2 concentration.



[Source: R. L. Garcia, S. P. Long, G. W. Wall, C. P. Osborne, B. A. Kimball, G. Y. Nie, P. J. Pinter, R. L. Lamorte and F. Wechsung (1998) 'Photosynthesis and conductance of spring-wheat leaves: field response to continuous free-air atmospheric CO2 enrichment.' *Plant, Cell and Environment*, **21**, pages 659–669.

a. Describe the pattern of CO_2 uptake in the control plants. [2]

b. Outline the effect of increased carbon dioxide concentration on CO_2 uptake. [2]

c. Discuss how CO_2 uptake in this investigation may be affected by other limiting factors. [3]

Markscheme

a. a. constant/low increase in February and early March;

b. increasing to a peak in late March;

c. decrease throughout April;

b. a. increased CO_2 leads to greater (rate of) photosynthesis;

b. greatest effect on March 30th;

c. smallest effect on April 28th;

d. effect is not constant / difference varies;

c. a. temperature/light intensity may be limiting factors;

b. temperature on sample days may have affected (rate of)photosynthesis/higher temperatures may increase (rate of) photosynthesis / vice versa;

c. light intensity may have affected (rate of) photosynthesis in earlier days/higher light intensity for longer may increase (rate of) photosynthesis /

vice versa;

d. water/rainfall must be same for both groups;

e. control and test plants must be grown under the same conditions/other named abiotic variable;

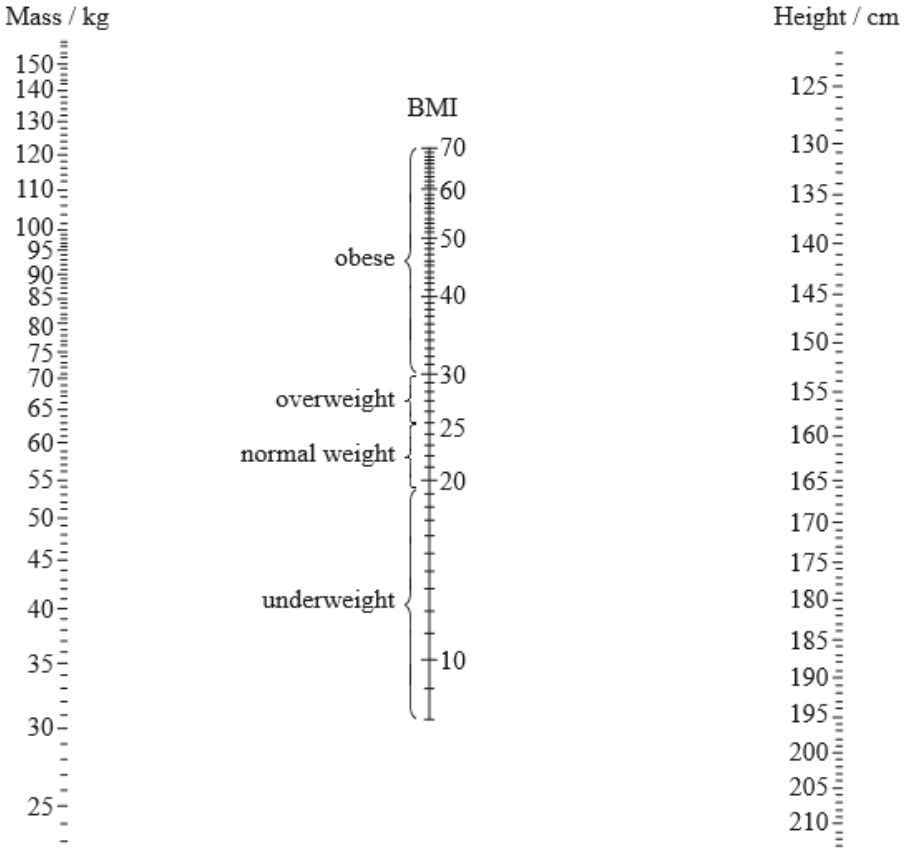
Examiners report

a. 7(a) was well answered.

b. Few recognized in (b) that there was not a constant difference between control and experimental plants.

c. In 7(c) the majority of candidates failed to relate their answers to the data presented, although they did get credit for some knowledge of limiting factors.

When assessing a patient's health, doctors very often calculate their body mass index (BMI). This is can be done using a nomogram as shown below.



[Source: http://www.domusmedica.be/documentatie/richtlijnen/overzicht/obesitas-volwassenen-horizontaalmenu-386.html. Used with permission.]

a. State the equation used to calculate the BMI including its units. [1]

b (i). Identify the mass above which a man whose height is 185 cm would be classified as obese. [1]

b (ii). A woman whose height is 167 cm has a mass of 78 kg. Calculate the minimum mass she should lose in order to have a normal BMI. [1]

c (i) A woman and a man both have a height of 170 cm. The woman has a mass of 30 kg and the man has a mass of 104 kg. [1]

Identify, using the nomogram, the BMI of both people.

The woman: .....

The man: .....

c (ii) A woman and a man both have a height of 170 cm. The woman has a mass of 30 kg and the man has a mass of 104 kg. [2]

Identify a possible cause of the BMI being too high or too low in the woman and in the man.

The woman: .....

The man: .....

d. Individuals whose appetite control centre does not function properly find it harder to avoid obesity. Outline the function of the appetite control centre. [2]

Markscheme

a. [N/A]

b (i) 125 (kg) (*accept answers in the range of 122 (kg) to 128 (kg*))

b (ii) 5 (kg) (*accept answers in the range of 4 (kg) to 6 (kg*))

c (i) *the woman*: 11 (kg m–2); (*accept answers in the range of 11.0 to 11.2*)

the man: 31 (kg m–2); (*accept answers in the range of 31.0 to 32.0*)

(*both needed*)

c (ii) *the woman*: anorexic / eating disorder / starvation / illness;

the man: overeating / lack of exercise / very muscular;

Do not accept "obesity", "glandular disorder" (too vague).

*Award **[1 max]** if "appetite control centre does not function properly" is mentioned.*

d. appetite control centre (in brain) makes person feel full/satiated/hungry;

function is both nervous and hormonal;

<u>after eating</u> (centre) responds to hormones/insulin from pancreas / hormones/PYY from small intestine / hormones from adipose tissue/leptin in response to fat storage;

(centre) responds to hormone/ghrelin released from empty stomach;

part (of the centre) responds to levels of lipid/sugar in the blood;

Examiners report

a. In 1(a), almost all candidates were able to correctly state the equation for BMI although some omitted the units.

b (i). In (b) (i) and (ii), candidates either got both correct or neither, depending on whether they knew how to use a nomogram.

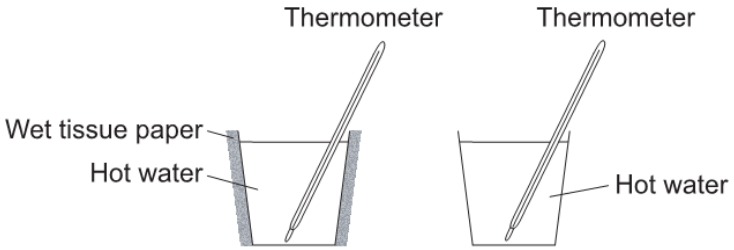
b (ii). In (b) (i) and (ii), candidates either got both correct or neither, depending on whether they knew how to use a nomogram.

c (i). Part (c) (i) was the same as (b), as the use of the nomogram was required to answer the question.

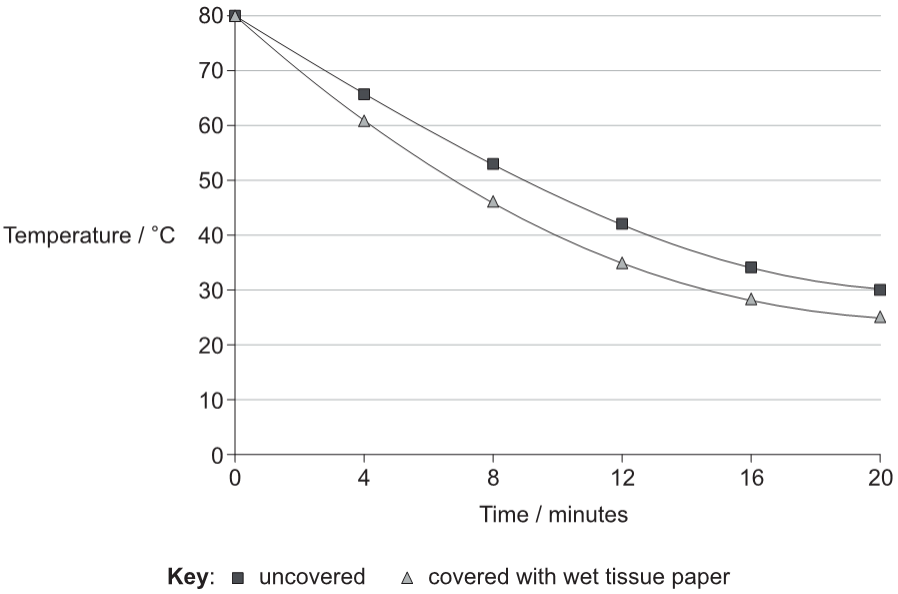
c (ii). In (c) (ii), most candidates were able to state a correct reason for the BMI being too high or too low, although a few simply said underweight or overweight, which did not earn any marks.

d. The weakest answers in Question 1 were seen in (d). Many candidates received one mark, for stating that the appetite control centre in the hypothalamus makes a person feel satiated or full but few received a second mark.

To investigate the thermal properties of water, students placed hot water in two thin plastic cups and measured their rate of cooling. The sides of one cup were covered with tissue paper soaked in hot water; the other cup was left uncovered. The temperature was recorded with a thermometer every 4 minutes for 20 minutes. The temperature in the laboratory was 18 °C.



[Source: © International Baccalaureate Organization 2017]



[Source: © International Baccalaureate Organization 2017]

a. Calculate the change in temperature in each cup after 20 minutes. [1]

Uncovered:

Covered with wet tissue paper:

b. State **two** conditions that must be the same for each cup at the start of the experiment. [2]

c. Predict the temperature of the water in the cups after 3 hours. [1]

d. Explain, with reference to the thermal properties of water, how this experiment helps demonstrate how humans respond to overheating. [3]

Markscheme

a. uncovered: 50 °C

covered with wet tissue paper: 55 °C

Both needed

Accept range 49 to 51 °C and 54 to 56 °C

Units required

Accept negative numbers (–50 °C and –55 °C)

Working on its own without an answer is insufficient for the mark (eg: 80 – 30)

b. a. volume/mass/amount of water they contain

b. temperature of water

c. placed in similar environment/on similar surface

OWTTE

d. «container must be» the same shape/size/volume/surface area

Do not award "ambient room temperature" or "material of cups"

Do not accept "type of water"

[Max 2 Marks]

c. 18 °C

OR

room temperature

If the answer is given as a numerical value then units are required

d. a. water has a high latent heat/high heat of vaporization

b. energy required to evaporate water «from the tissue paper»

c. evaporation of water leads to cooling

d. sweat produced by skin in response to heat

e. «evaporation of» sweat cools the body

Do not accept specific heat

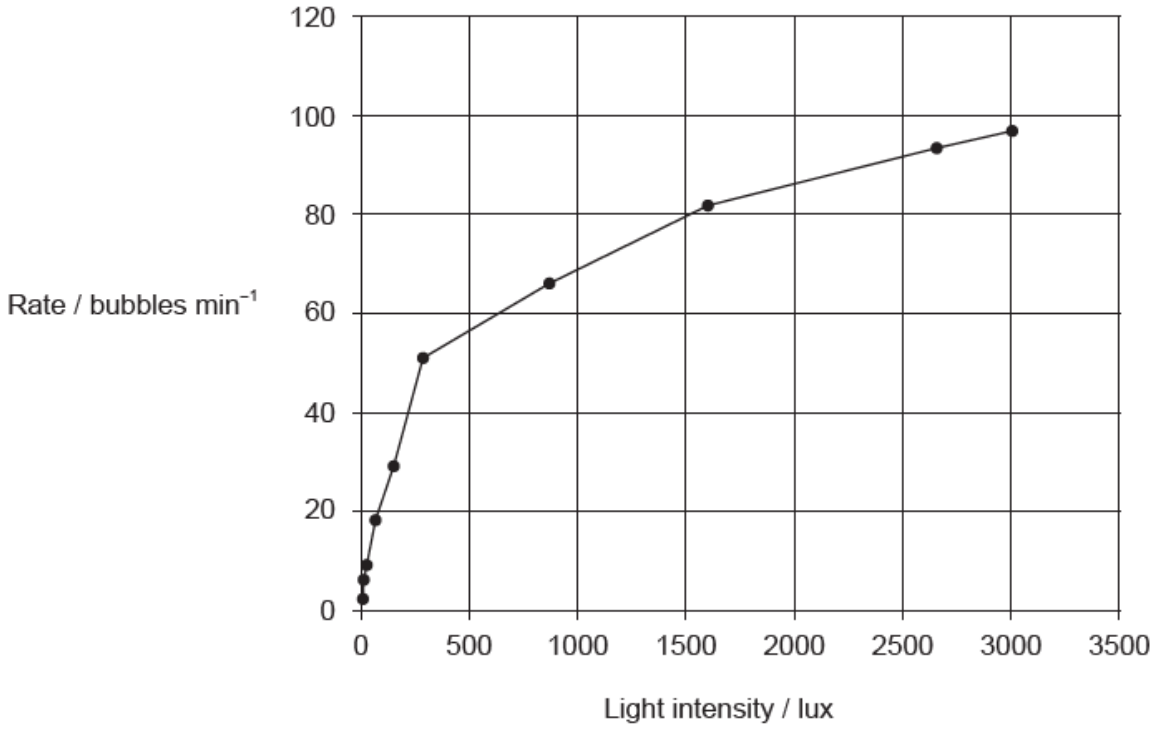
[Max 3 Marks]

Examiners report

[N/A]

b. [N/A]
c. [N/A]
d. [N/A]

Students exposed the water plant *Cabomba caroliniana* to different light intensities. The bubbles of oxygen gas released by the plant were counted each minute.



a. Compare and contrast the experimental results for the effect of light intensity on the rate of photosynthesis of a green plant with the expected trend line. [2]

b. *C. caroliniana* can grow well in water at 27°C. This experiment was carried out at 25°C. [1]

Describe the effect of carrying out the same experiment at 15°C.

c. This experiment measured the quantity of oxygen gas released by the water plant. State **one** other way of measuring the rate of photosynthesis. [1]

Markscheme

a. *Compare:*

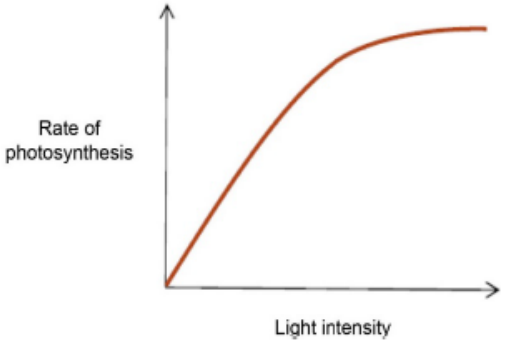
a. both the theoretical data and the experimental data show an increase in photosynthetic rate/oxygen production with increased light intensity
OR
the rate of photosynthesis in the experimental data starts to level off at high light intensity as expected in theoretical data

Contrast:

b. the experimental data do not reach a plateau whereas theoretical data do
OR
data show photosynthesis is occurring at zero lux/light intensity whereas theoretical data would not

Accept answers using an annotated graph.

Accept answers as annotations of the graph or a new graph drawn:



b. «the rate of photosynthesis» would be slower/fewer bubbles

OR

rise to lower level/would plateau at a lower level/would be half the height

c. a. measure the absorption/decrease of CO_2

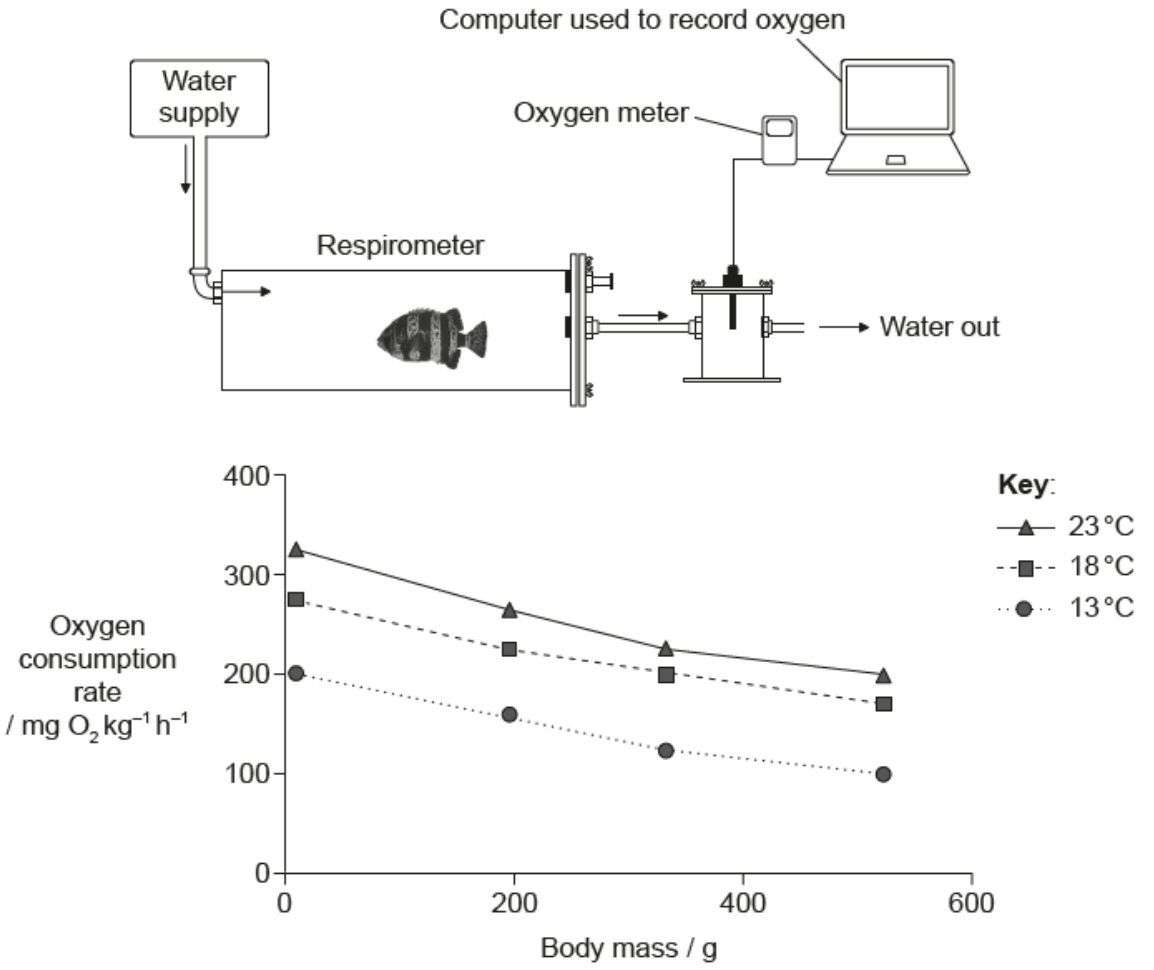
b. measure the increase in biomass

c. measure rise in pH

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

The oxygen consumption rate of the fish *Oplegnathus insignis* was examined in a respirometer at three different water temperatures and at four different body masses.



[Source: adapted from E Segovia, *et al.*, (2012), *Latin American Journal of Aquatic Research*, **40** (3), pages 766–773]

a. Suggest how the oxygen consumption rate is determined using this apparatus. [2]

b. State the relationship between body mass and the oxygen consumption of fish. [1]

c. Predict the effects of global warming on aerobic respiration in fish. [2]

Markscheme

a. a. the data logger measures the differences in oxygen concentration

OR

the oxygen concentration is measured before and after the water passes through the respirometer

b. over time

c. the mass of fish needs to be measured

b. greater body mass, less consumption of oxygen

OR

indirect/negative relationship

c. a. higher temperature, more oxygen consumption

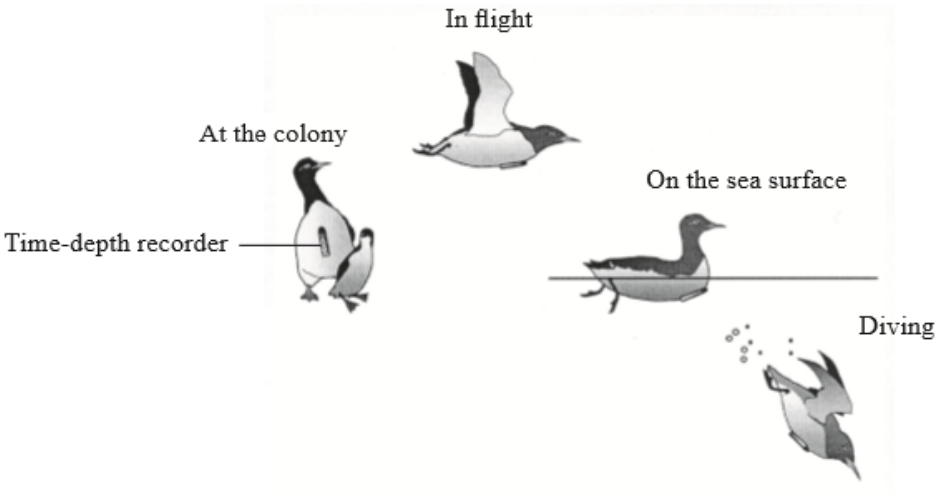
b. «more oxygen consumption» is due to more respiration/metabolism

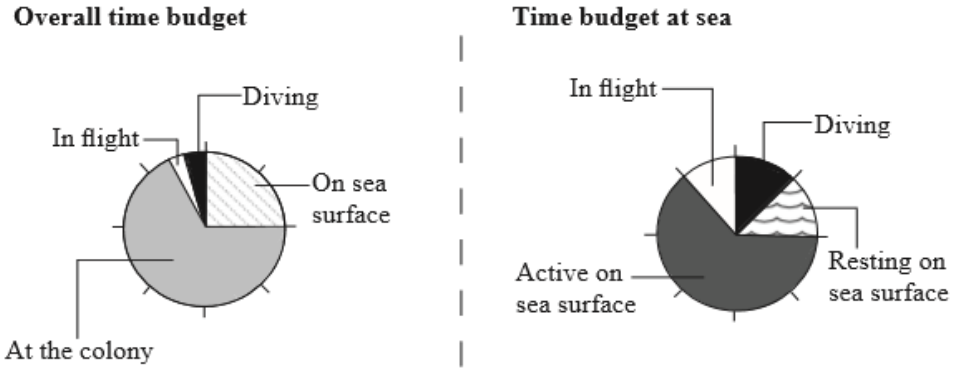
c. less oxygen can dissolve in warmer water so less «aerobic» respiration
OR
more carbon dioxide dissolved so less oxygen for respiration

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

Common guillemots (*Uria aalge*) are large sea birds of the auk family. They breed in colonies at high densities but make no nest. Their single egg is incubated on bare rock. Alloparenting behaviour is frequently observed, where non-breeding birds will take care of other chicks. Scientists fitted electronic time-depth recorders onto twelve common guillemots and recorded five different activities during the chick-rearing period: at the colony, in flight, resting or active on the sea surface and diving. The pie charts below include pooled data from all birds showing overall time budget and time budget at sea.





a. State which activity takes up least of the overall time budget of the guillemots. [1]

b. Calculate the percentage of the overall time budget the guillemots spend resting on the sea surface. [1]

.....%

c. Outline the activity of guillemots at sea. [2]

d. Suggest **two** reasons, other than breeding, why birds spend more time at the colony than any other activity. [2]

Markscheme

a. in flight

b. 1

4

× 1

6

×100;

4.2 (%); (*Allow answers from 4 % to 4.2 %*)

c. birds spend most of time active on the water;

more or less the same time in flight, diving and resting in water; *Need all three parts for the mark.*

d. birds need to rest/sleep to recover energy/digest food / are inactive at night;

moulting makes them flightless;

defending territory / protection of young / other example of social behaviour;

Examiners report

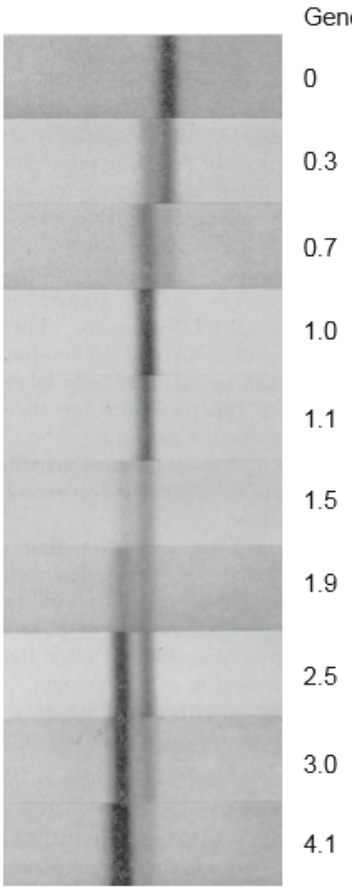
a. The correct answer of “in flight” was given by most students.

b. This was probably the most challenging calculation question on the paper, and many candidates found the information in the pie charts difficult to interpret. However, a few strong candidates were able to answer correctly.

c. The majority realised that the birds spent about the same time in flight, diving and resting in the water, but spent more time active on the water, so gained two marks for this question.

d. Most candidates could give two correct reasons for birds spending more time at the colony.

Over 50 years ago, Meselson and Stahl investigated the mechanism of DNA replication. They transferred a rapidly growing population of *Escherichia coli* from a growth medium containing only ^{15}N to a growth medium with only ^{14}N. DNA samples were centrifuged at high speed in a salt density gradient. In the original published research, DNA molecules of the same density appear as a band in the UV absorption photographs as shown.



[Source: M. Meselson and F. W. Stahl (1958) 'The Replication of DNA in Escherichia coli.' *PNAS*, 44, pp. 671–682, Figure 4a. Used with the authors' permission.]

a. The density of the DNA band at generation 0 is 1.724 and the density of the dark band of DNA at generation 4.1 is 1.710. Estimate the density of the DNA band at generation 1.0. [1]

b. Describe the nitrogen composition of the DNA band in the *E. coli* at generation 1.0. [1]

c. Explain the pattern shown in generation 3.0. [3]

d. This experiment was designed to demonstrate whether replication was semi-conservative or conservative. Distinguish between semi-conservative replication and conservative replication. [2]

Markscheme

a. 1.717

b. Half ^{14}N and half ^{15}N

OR

one/new strand ^{14}N and one/old strand ^{15}N

OR

half labelled

Must indicate equal quantities eg: 50 % of each or 1 strand of each

c. «As replication is semi-conservative» each new strand is built on parental/old/template strand (*Do not give a mark for "semi-conservative"*)

Generation 3 shows DNA that is mostly made of ^{14}N

When *E. coli* replicates, half of its new DNA must always contain ^{14}N when growing in a ^{14}N growth medium

Every new generation of *E. coli* always has a smaller proportion of «labelled» ^{15}N in its DNA «than the previous generation»

Each new generation has half the amount of ^{15}N in previous generation

Accept answers in an annotated diagram

d.

semi-conservative	conservative
«daughter» DNA is half parental	«daughter» DNA is all parental ***OR*** all «daughter» DNA is new
one strand of the «daughter» DNA is new	«daughter» DNA is all parental ***OR*** all «daughter» DNA is new
both strands of parental DNA are separated	both strands of parental DNA remain together

Table format not required

Examiners report

a. Question 2 on the Meselson and Stahl investigation was generally problematic and very poorly answered though a few candidates did score high marks.

b. Question 2 on the Meselson and Stahl investigation was generally problematic and very poorly answered though a few candidates did score high marks.

c. The majority of candidates described the shading and densities as opposed to explaining the pattern in terms of the N present in the DNA.

d. Many candidates scored 2 marks distinguishing between semi-conservative and conservative replication.