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]

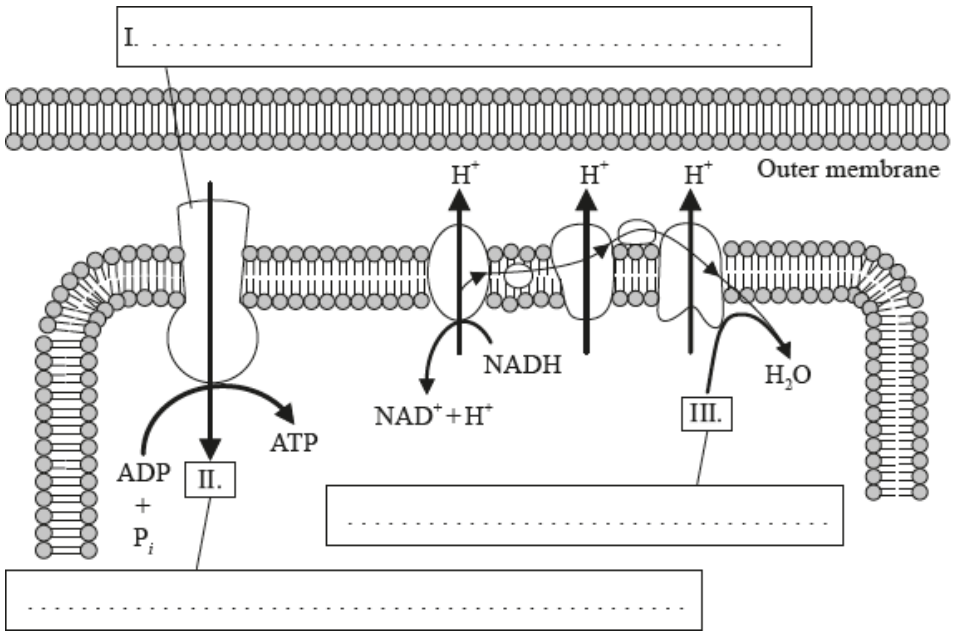
a. State the names and functions of the antagonistic muscles of the human elbow joint. [2]

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

Outline the variation in the structure of fatty acids.

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]

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

Primary protein structure:

Quaternary protein structure:

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

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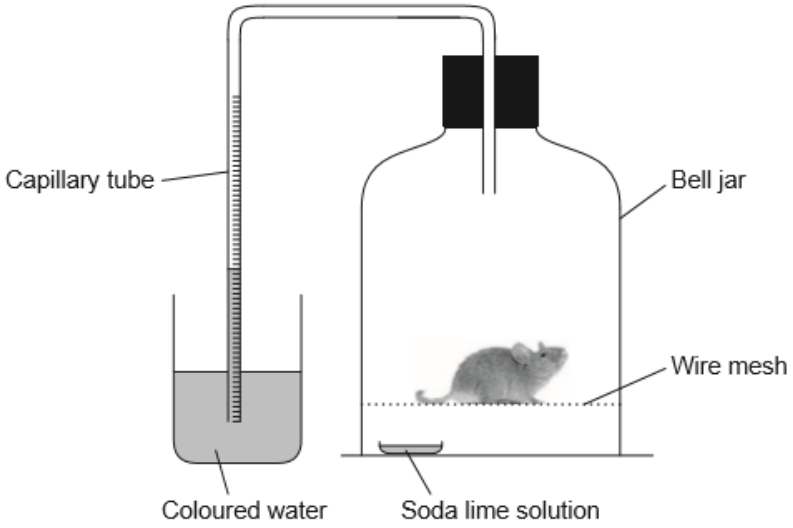
a. List **three** functions of proteins, giving a **named** example of each. [3]

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

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]

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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]

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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]

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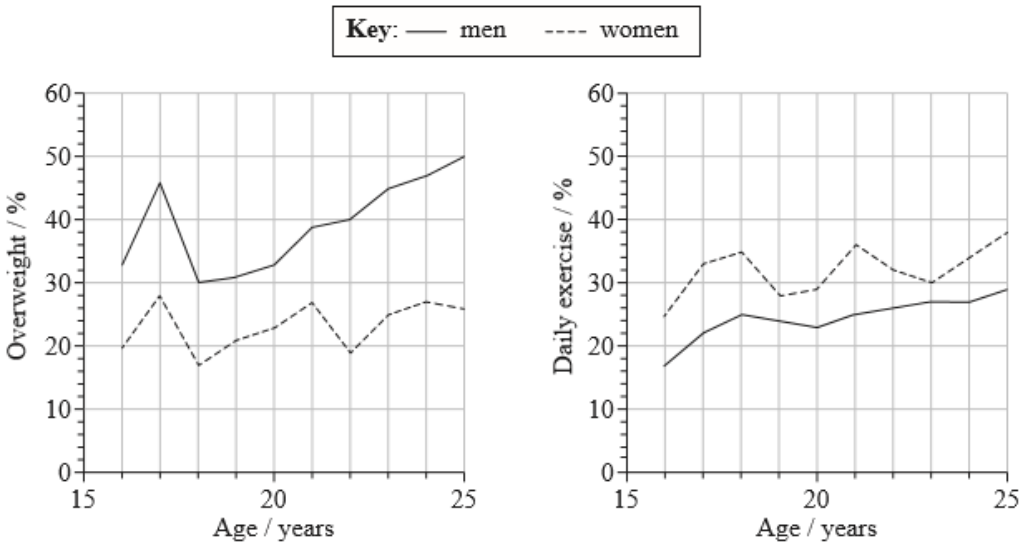
a. Outline the molecular structure of different types of fatty acids. [3]

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

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]

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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]

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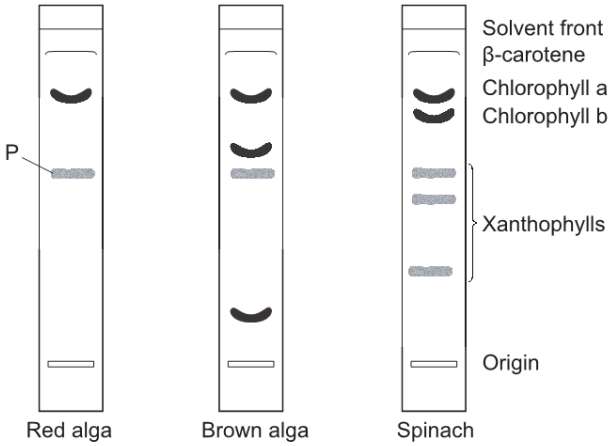
a. List **two** possible variants in the molecular structure of unsaturated fatty acids. [2]

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

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

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.

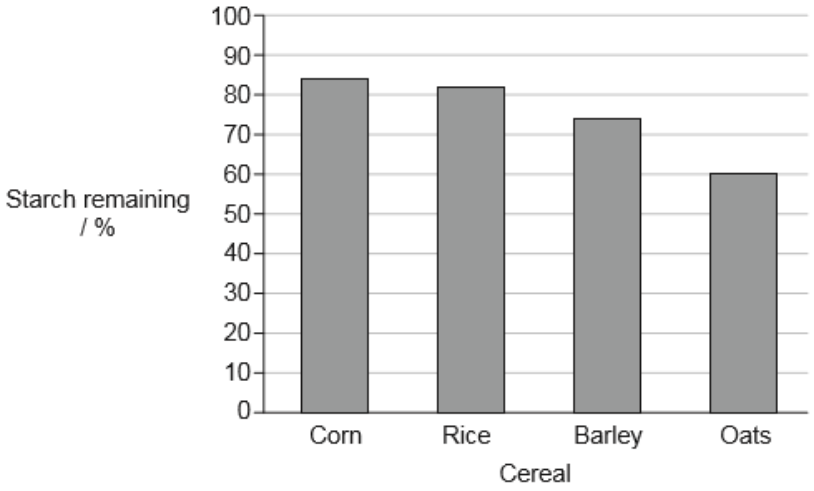


a. Identify pigment labelled P. [1]

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]

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]

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]

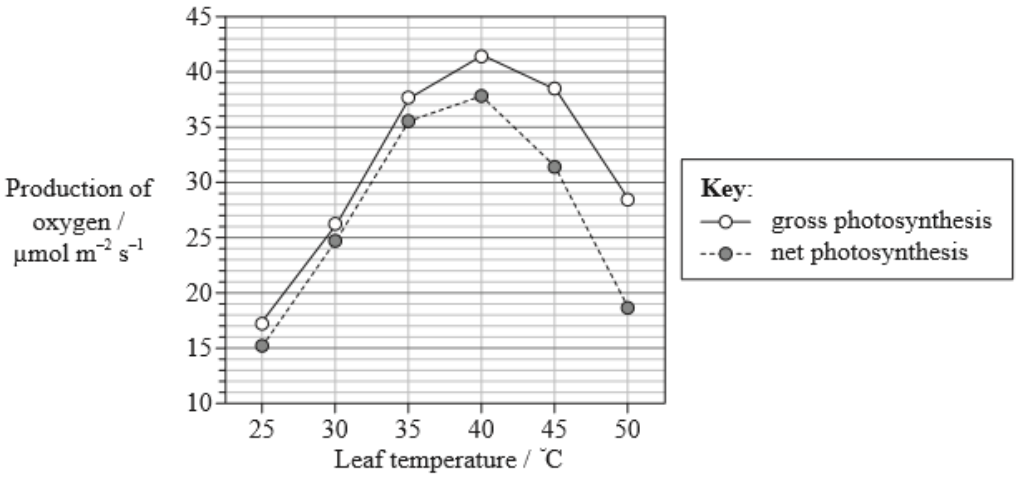
b. One result in this experiment can be classified as an outlier as its value is very distant from those of the other values. [2]

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]

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: .....

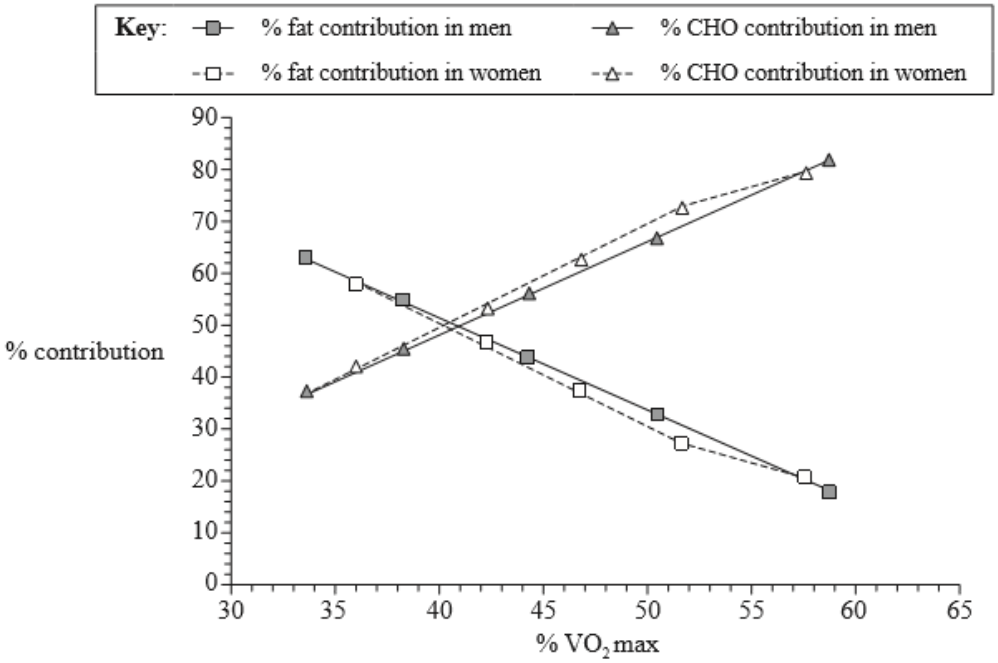
50 °C: .....

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]

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.

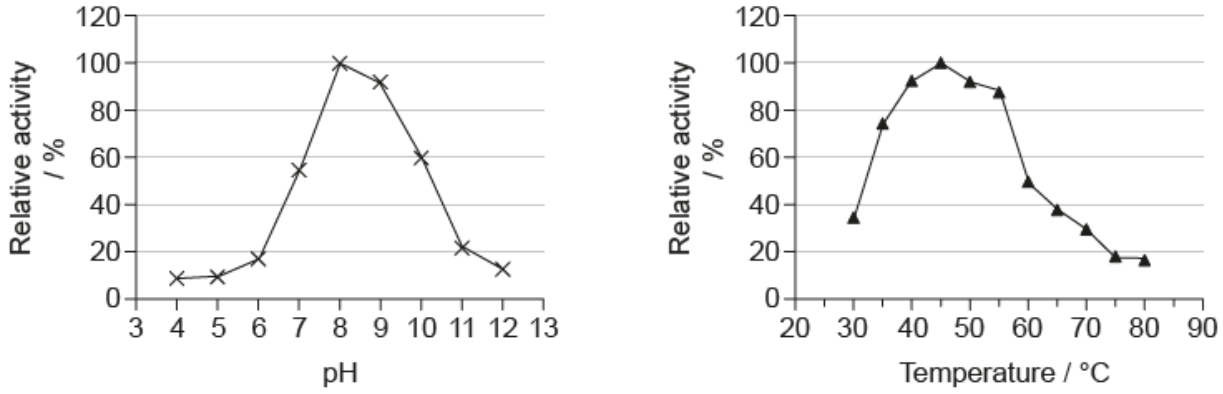
b. State the percentage contribution of the different sources of energy at 36% VO_2 max in women. [1]

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]

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.



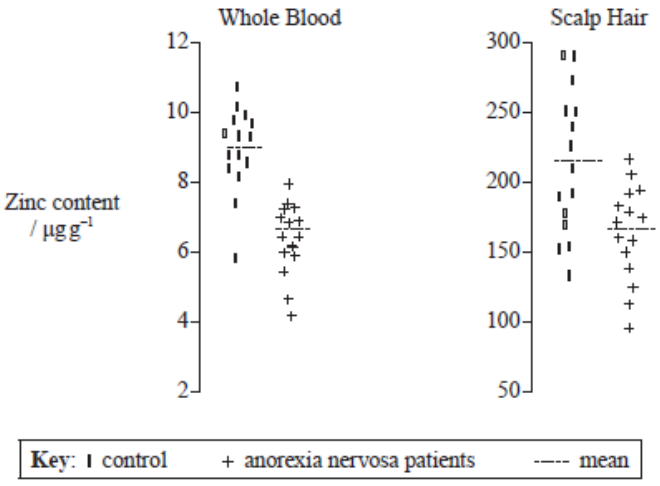
[Source: Kim Jeong-Dong (2007) 'Purification and Characterization of a Keratinase from a Feather-Degrading Fungus, *Aspergillus flavus* Strain K-03.' *Mycobiology*, 35(4), pages 219–225]

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]

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]

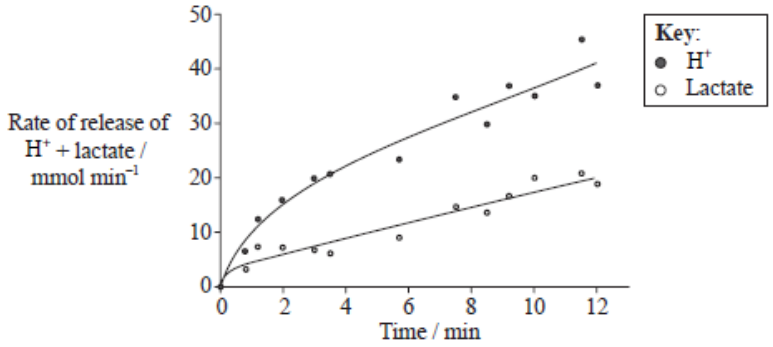
c. Discuss whether dietary zinc supplementation would be an effective treatment for anorexia nervosa. [2]

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]

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.



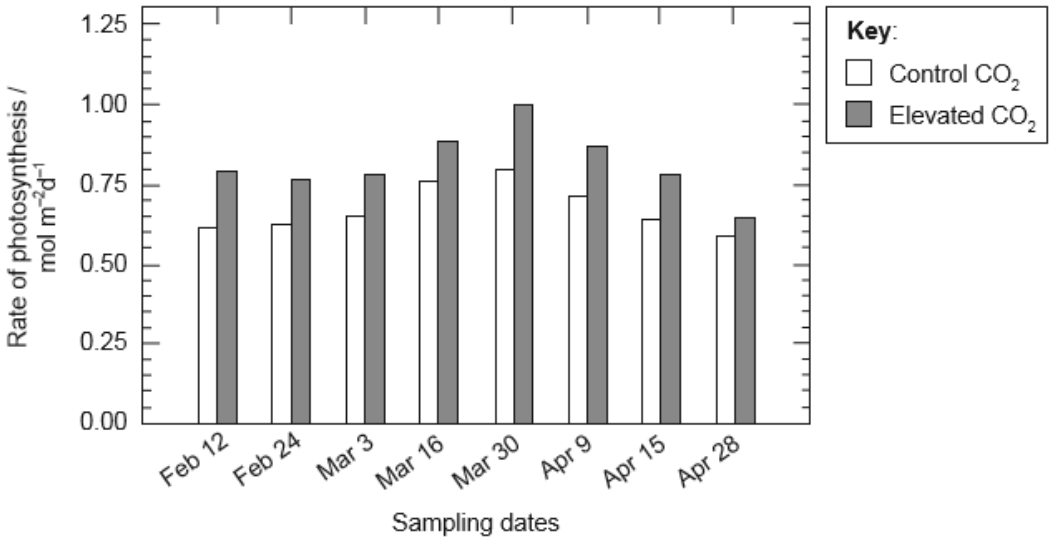
[Source: Figure 6 , Carsten Juel, Christina Klarskov, Jens Jung Nielsen, Peter Krustrup, Magni Mohr, Jens Bangsbo. "Effect of high-intensity intermittent training on lactate and H+ release from human skeletal muscle." *American Journal of Physiology Endocrinology and Metabolism* 286: E245-E251, 2004. 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]

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.



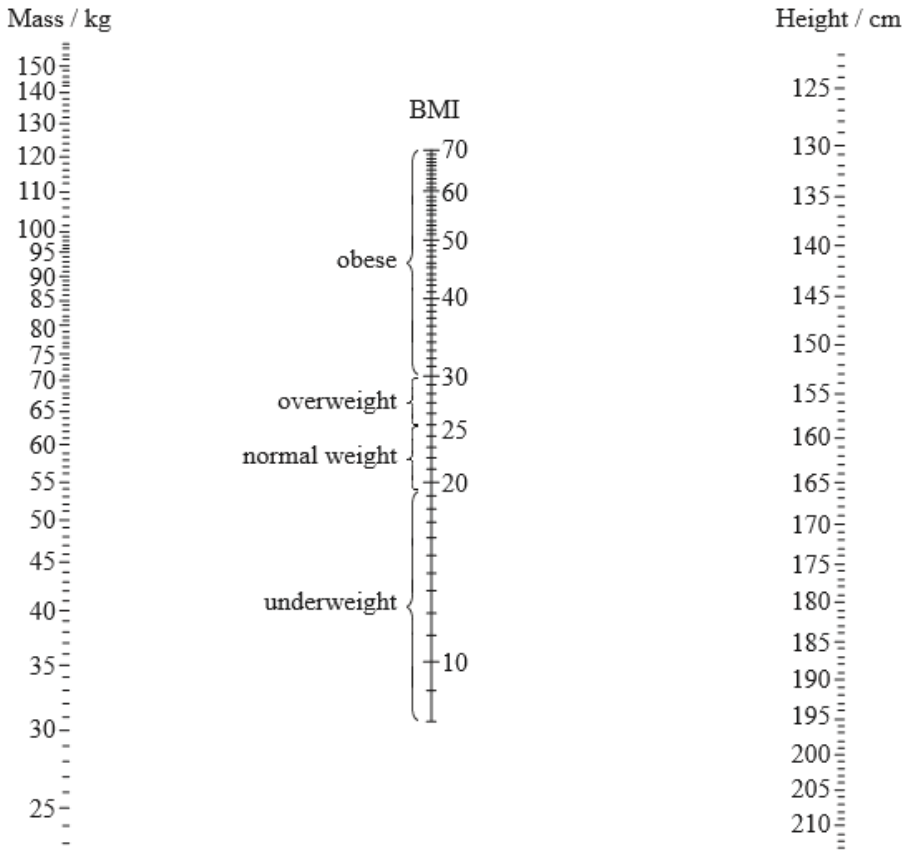
[Source: R. L. Garcia, S. P. Long, G. W. Wall, C. P. Osborne, B. A. Kimball, G. Y. Nie, P. J. Pinter, R. L. Lamorte and F. Wechsung (1998) 'Photosynthesis and conductance of spring-wheat leaves: field response to continuous free-air atmospheric CO2 enrichment.' *Plant, Cell and Environment*, **21**,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

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]

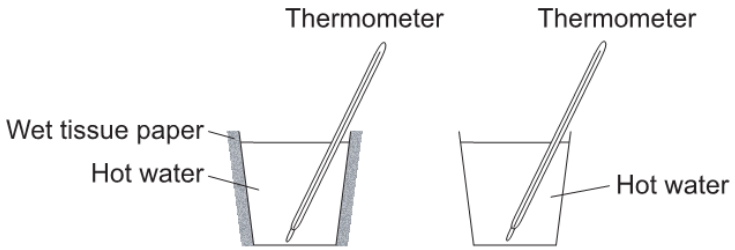
Identify a possible cause of the BMI being too high or too low in the woman and in the man.

The woman: .....

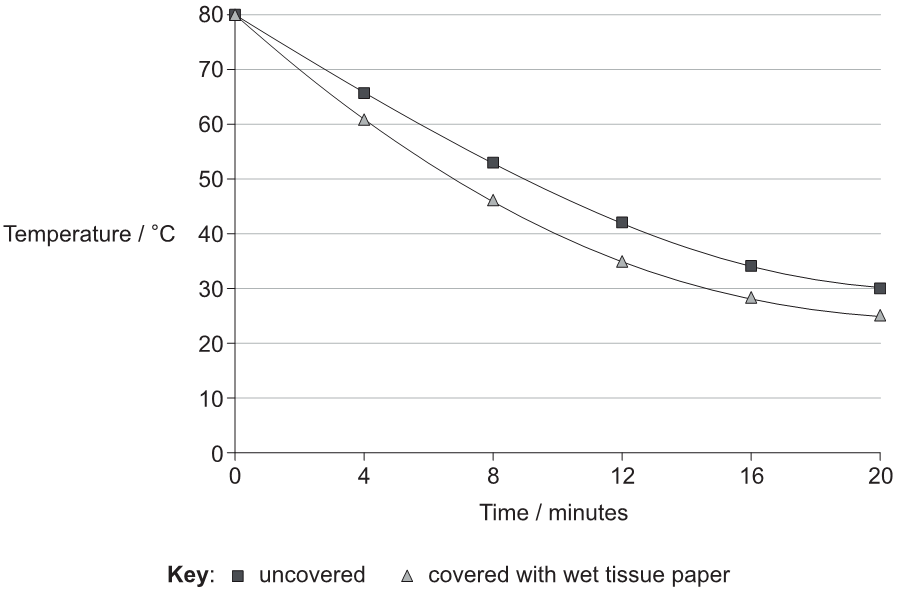
The man: .....

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]

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:

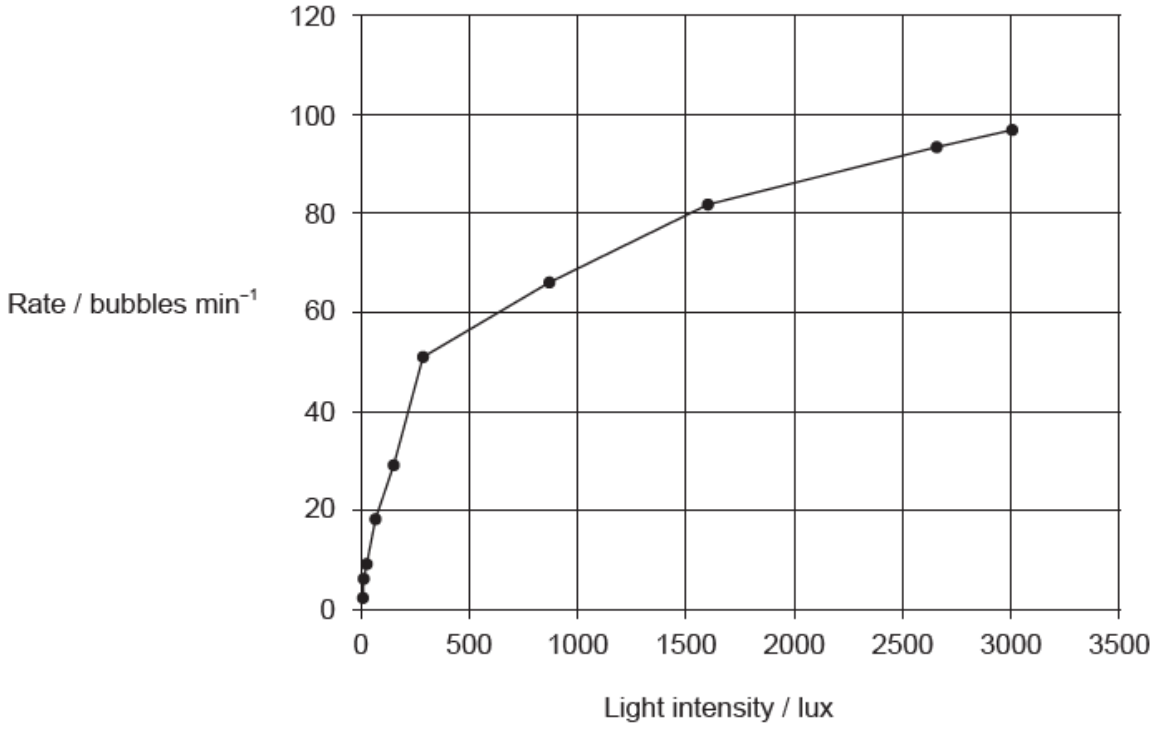
Covered with wet tissue paper:

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]

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



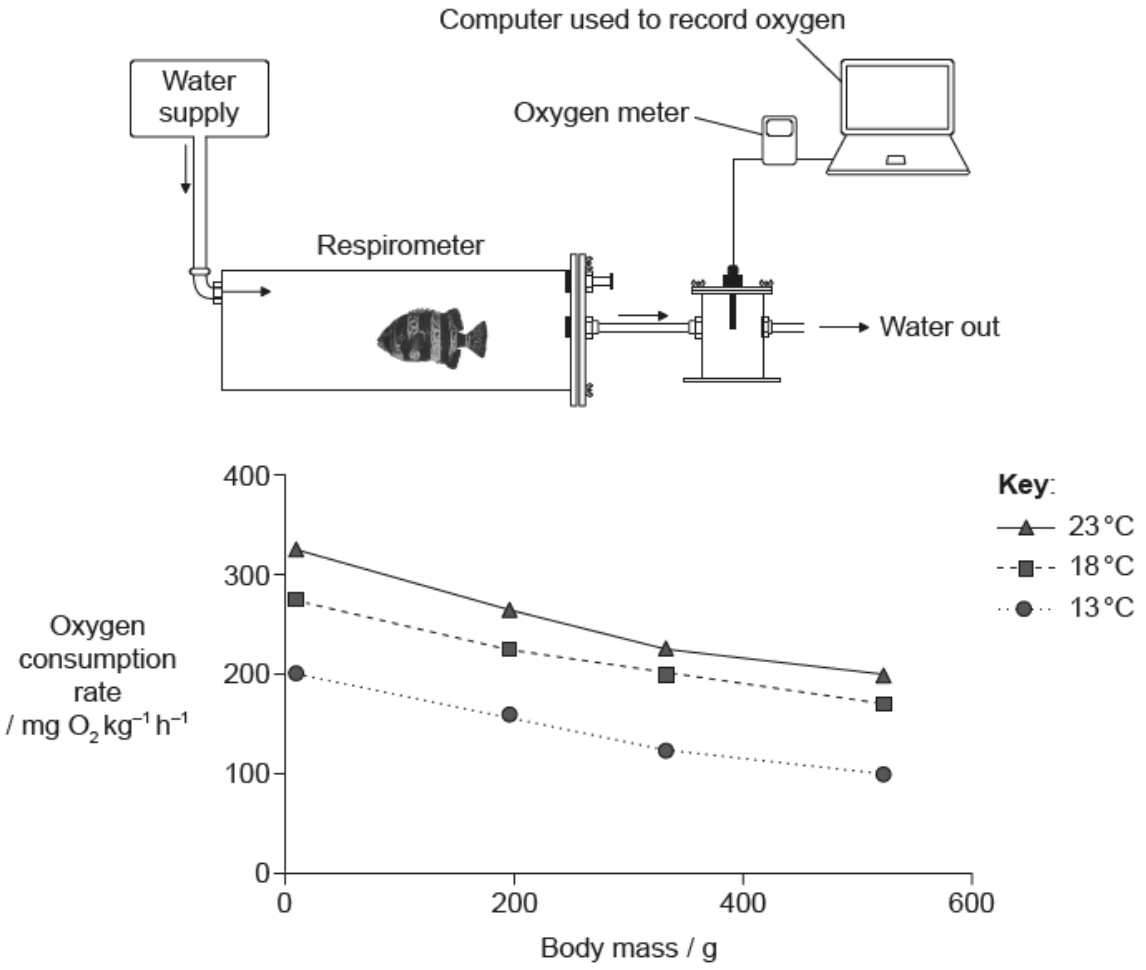
a. Compare and contrast the experimental results for the effect of light intensity on the rate of photosynthesis of a green plant with the expected trend line. [2]

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]

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.



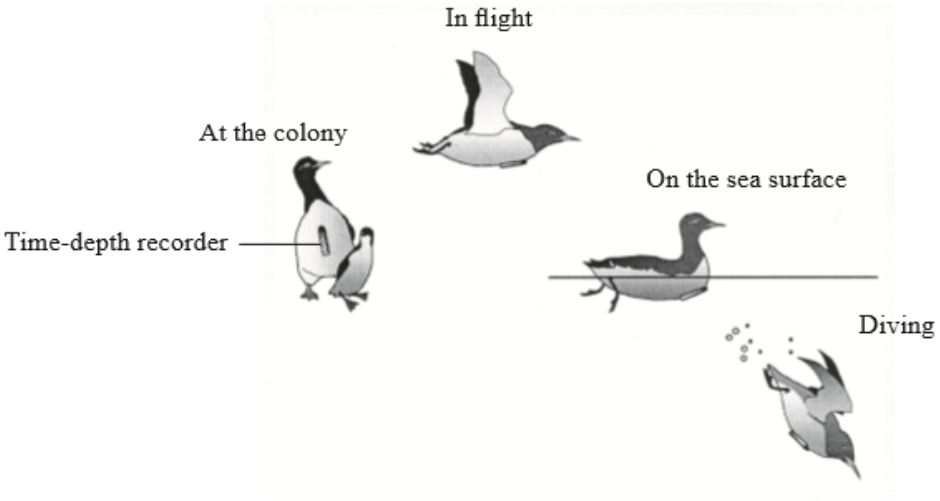
[Source: adapted from E Segovia, *et al.*, (2012), *Latin American Journal of Aquatic Research*, **40** (3), pages 766–773]

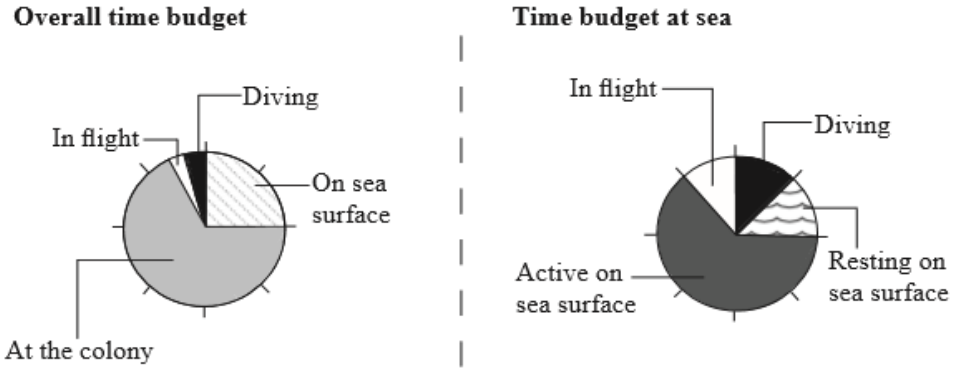
a. Suggest how the oxygen consumption rate is determined using this apparatus. [2]

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]

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]

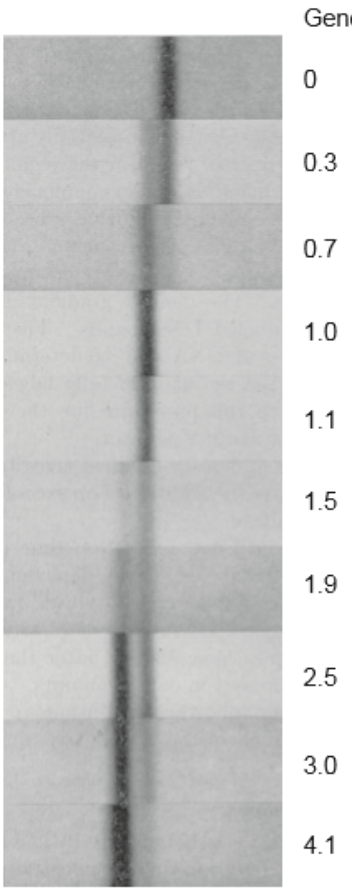
b. Calculate the percentage of the overall time budget the guillemots spend resting on the sea surface. [1]

.....%

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]

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]