1.9 A-Level Biology: Required Practicals and Data Analysis: 1-hour Pack

AQA 7402 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A student investigated the rate of the enzyme-catalysed breakdown of hydrogen peroxide (H_2O_2) by catalase in potato tissue, using a gas syringe to collect the oxygen produced over 60 seconds at 25°C, for a dilution series of H_2O_2 concentrations.

H_2O_2 concentration (%): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

Volume of O_2 collected in 60 s (cm^3): 6, 13, 19, 24, 26, 27

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

(b) State one variable that should be controlled in this investigation. **(1)**

(c) Calculate the rate of reaction at 1.5% H_2O_2, in $cm^3\ s^{-1}$, to 3 significant figures. **(2)**

(d) Explain the shape of the graph of rate against H_2O_2 concentration between 2.0% and 3.0%. **(3)**

(e) Suggest why the student used a water bath at a constant temperature rather than carrying out the reaction at room temperature. **(2)**

(Total for Question 1 is 9 marks)

© Revision Library | revisionlibrary.co.uk

2 A student investigated water potential in potato tissue using a dilution series of sucrose solution. Potato cylinders (4 cm length, cut with the same cork borer) were blotted, weighed, placed into sucrose solutions of 0.0 to 1.0 mol dm^{-3} for 24 hours, then reweighed.
Sucrose concentration (mol dm^{-3}): 0.0, 0.2, 0.4, 0.6, 0.8, 1.0
Percentage change in mass (%): +8.2, +3.1, -1.5, -6.0, -10.4, -14.9
Water potential of each sucrose solution (kPa): 0, -540, -1120, -1780, -2520, -3350

Sucrose concentration (mol dm^{-3})	Percentage change in mass (%)	Water potential (kPa)
0.0	+8.2	0
0.2	+3.1	-540
0.4	-1.5	-1120
0.6	-6.0	-1780
0.8	-10.4	-2520
1.0	-14.9	-3350

(a) One potato cylinder had an initial mass of 4.85 g and a final mass of 4.50 g. Calculate the percentage change in mass, to 3 significant figures, stating whether this is a gain or a loss. **(2)**

(b) Using the data table, estimate by interpolation the sucrose concentration at which the percentage change in mass would be zero, and use the water potential values given to estimate the water potential of the potato tissue. **(2)**

(c) Explain, in terms of water potential, why the potato cylinder placed in distilled water increased in mass. **(2)**

(d) State two variables that should be controlled in this investigation to ensure valid results. **(2)**

(Total for Question 2 is 8 marks)

© Revision Library | revisionlibrary.co.uk

3 A student investigated the effect of light intensity on the rate of photosynthesis of Cabomba pondweed by counting the number of oxygen bubbles produced per minute at different distances from a lamp.

Distance from lamp (cm): 10, 20, 30, 40, 50

Bubbles produced per minute: 48, 22, 11, 7, 5

(a) Light intensity is proportional to $1/d^2$, where d is the distance from the lamp. Calculate the ratio of light intensity at 20 cm to light intensity at 40 cm. **(2)**

(b) The number of bubbles produced per minute is 22 at 20 cm and 7 at 40 cm. Comment on whether this is consistent with the prediction from part (a). **(2)**

(c) Suggest two variables that should be controlled to ensure a valid comparison at each distance. **(2)**

(d) Explain one limitation of using the rate of bubble production as a measure of the rate of photosynthesis, and suggest how this could be improved. **(2)**

(Total for Question 3 is 8 marks)

© Revision Library | revisionlibrary.co.uk

4 A student investigated the effect of caffeine on the heart rate of Daphnia (water fleas), using a control group (0% caffeine solution) and a treatment group (0.5% caffeine solution), with six replicates in each group.

Heart rate, control 0% caffeine (beats per minute): 148, 152, 145, 150, 149, 151

Heart rate, 0.5% caffeine (beats per minute): 168, 172, 165, 170, 175, 169

(a) Calculate the mean heart rate for the control group (0% caffeine), to 1 decimal place. **(2)**

(b) The mean heart rate for the 0.5% caffeine group is 169.8 bpm. Calculate the standard deviation of heart rate for this group, using SD = $\sqrt{\text{sum}(x - \text{mean})^2 / (n - 1)}$. Give your answer to 3 significant figures. **(3)**

(c) A t-test comparing the two groups gives a calculated t-value of 12.0. The critical value at p = 0.05 for 10 degrees of freedom is 2.23. State, with reference to both values, whether caffeine has a statistically significant effect on Daphnia heart rate, and explain why a t-test, rather than a chi-squared test, is the appropriate statistical test to use here. **(2)**

(d) Suggest and explain one ethical issue that should be considered when using Daphnia in this type of investigation, and one modification to the experimental design that would help address it. **(3)**

(Total for Question 4 is 10 marks)

© Revision Library | revisionlibrary.co.uk

5 A student investigated the effect of temperature on the permeability of beetroot cell-surface membranes. Equal-sized beetroot discs were placed in water baths at different temperatures for 10 minutes, then the absorbance of the resulting pigment (betalain) solution was measured using a colorimeter.

Temperature (°C): 10, 20, 30, 40, 50, 60

Absorbance (arbitrary units): 0.05, 0.08, 0.15, 0.42, 0.71, 0.88

(a) Explain why a colorimeter, rather than visual comparison of colour, was used to measure pigment leakage. **(2)**

(b) Calculate the percentage increase in absorbance between 30°C and 40°C. **(2)**

(c) A Pearson's product-moment correlation coefficient calculated for temperature against absorbance across the full data set gives r = +0.96. State what this value shows about the relationship, and explain, in terms of membrane structure, why absorbance increases so sharply between 30°C and 50°C. **(3)**

(d) State two variables that must be standardised between the beetroot discs used at each temperature to ensure a valid comparison. **(2)**

(Total for Question 5 is 9 marks)

© Revision Library | revisionlibrary.co.uk

Mark scheme · 1.9 A-Level Biology: Required Practicals and Data Analysis: 1-hour Pack

Question 1

(a) concentration of hydrogen peroxide **B1**

(a) Answer: Concentration of hydrogen peroxide

(b) any one of: temperature; volume of H_2O_2 used; mass/surface area of potato tissue; time allowed for reaction (any one, ora) **B1**

(b) Answer: Temperature (or volume of H_2O_2, or mass/surface area of potato)

(c) 19 / 60 **M1**

(c) 0.317 cm^3 s^{-1} (awrt 0.317) cao **A1**

(c) Answer: 0.317 cm^3 s^{-1}

(d) the rate increases only slightly / levels off (plateaus) **B1**

(d) because enzyme (catalase) concentration is now the limiting factor **B1**

(d) all active sites are occupied/saturated at any one time, so increasing substrate concentration further has little/no effect on rate **B1**

(d) Answer: Rate levels off because enzyme concentration becomes limiting once all active sites are saturated

(e) to keep temperature constant across all repeats/concentrations **B1**

(e) because temperature affects rate of reaction (kinetic energy of molecules/enzyme activity), so an uncontrolled temperature would be a confounding variable affecting the validity of the comparison **B1**

(e) Answer: Keeps temperature constant so it does not act as a confounding variable, since temperature affects reaction rate

Question 2

(a) (4.50 - 4.85) / 4.85 x 100 (correct substitution) **M1**

(a) -7.22% / a 7.22% decrease (awrt 7.22) cao **A1**

(a) Answer: -7.22% (a 7.22% decrease in mass)

(b) correct interpolation between 0.2 mol dm^{-3} (+3.1%) and 0.4 mol dm^{-3} (-1.5%) to give a concentration of approximately 0.33-0.34 mol dm^{-3} **M1**

(b) water potential of tissue approximately -930 kPa (accept -900 to -960 kPa), ft from their concentration **A1**

(b) Answer: Approximately 0.335 mol dm^{-3}; water potential approximately -930 kPa

(c) distilled water has a higher (less negative) water potential than the water potential of the cells inside the potato tissue **B1**

(c) water moves by osmosis, from a region of higher (less negative) water potential to a region of lower (more negative) water potential, across the partially permeable cell-surface membrane **B1**

(c) Answer: Water moves into the cells by osmosis, down the water potential gradient, because distilled water has a higher water potential than the potato cells

(d) any one of: temperature; time left in solution; dimensions/surface area of potato cylinders; volume of solution used **B1**

(d) any second, different variable from the list above **B1**

(d) Answer: Any two of: temperature, time in solution, size of potato cylinders, volume of solution

Question 3

(a) $1/20^2$: $1/40^2$ = 1/400 : 1/1600 (correct substitution) **M1**

(a) ratio = 4 : 1 cao **A1**

(a) Answer: 4 : 1

(b) actual ratio = 22 : 7, approximately 3.1 : 1 **B1**

(b) this is lower than the predicted 4:1 ratio, e.g. because light intensity may not be the only limiting factor at these distances (for example CO_2 concentration or temperature may limit the rate near the lamp), or because counting bubbles is not an accurate measure of the volume of oxygen produced (any suitable evaluative point) **B1**

(b) Answer: Actual ratio approximately 3.1:1, lower than the predicted 4:1, suggesting another factor may be limiting or that bubble counting is imprecise

(c) any one of: temperature (e.g. using a water bath); CO_2/hydrogencarbonate concentration; length/species of pondweed; time period over which bubbles are counted **B1**

(c) any second, different variable from the list above **B1**

(c) Answer: Any two of: temperature, CO_2 concentration, length of pondweed, counting time

(d) bubbles may vary in size/volume, so counting the number of bubbles does not accurately measure the volume of oxygen produced **B1**

(d) improvement: collect the gas (e.g. in a syringe or capillary tube) and measure its volume directly instead of counting bubbles **B1**

(d) Answer: Bubble size varies, so counting bubbles is inaccurate; collecting and measuring the volume of gas directly would improve this

© Revision Library | revisionlibrary.co.uk

Question 4

(a) sum of values (895) / 6 **M1**

(a) 149.2 bpm (awrt 149.2) cao **A1**

(a) Answer: 149.2 beats per minute

(b) correct deviations from the mean for at least four of the six values **M1**

(b) sum of squared deviations (approximately 58.8) divided by (n - 1) = 5, giving variance approximately 11.8 **M1**

(b) SD = 3.43 bpm (awrt 3.4-3.5) cao **A1**

(b) Answer: 3.43 beats per minute

(c) the calculated value (12.0) exceeds the critical value (2.23), so the difference is statistically significant (the null hypothesis is rejected) **B1**

(c) a t-test is appropriate because the data are continuous/numerical (comparing two means), whereas chi-squared is used for categorical/frequency data **B1**

(c) Answer: Significant, since 12.0 > 2.23; t-test is appropriate for continuous data (comparing means), not categorical data

(d) Daphnia are living organisms and caffeine may cause them stress, harm or death, particularly at higher concentrations, raising an animal welfare concern **B1**

(d) modification: use the lowest concentration and shortest exposure time needed to obtain valid results, and return/dispose of Daphnia appropriately and promptly after data collection, following the school's animal welfare/ethical guidelines **B1**

(d) a control group (0% caffeine) should be used so that any effect of caffeine can be distinguished from effects of handling/environmental disturbance alone **B1**

(d) Answer: Welfare concern from possible harm/stress to Daphnia; minimise concentration/exposure time and use a control group to isolate the caffeine effect

Question 5

(a) a colorimeter gives objective, quantitative/numerical readings **B1**

(a) which are more precise and reliable, and reduce/remove observer bias, compared with judging colour by eye **B1**

(a) Answer: A colorimeter gives objective, quantitative readings, reducing bias compared to judging colour by eye

(b) (0.42 - 0.15) / 0.15 x 100 (correct substitution) **M1**

(b) 180% cao **A1**

(b) Answer: 180%

(c) a strong positive correlation between temperature and absorbance (pigment leakage) **B1**

(c) as temperature increases, absorbance/pigment leakage increases **B1**

(c) increasing temperature gives phospholipids and proteins in the cell-surface membrane more kinetic energy, disrupting/denaturing the membrane structure (e.g. increased fluidity of the phospholipid bilayer, denaturation of channel/carrier proteins), so the membrane becomes more permeable and more betalain pigment leaks out of the vacuole **B1**

(c) Answer: Strong positive correlation; increased temperature disrupts/denatures membrane structure, increasing permeability and pigment leakage

(d) any one of: size/surface area of beetroot discs; time in the water bath; volume of water/solution used; time before colorimeter reading; same source/species of beetroot **B1**

(d) any second, different variable from the list above **B1**

(d) Answer: Any two of: disc size, time in water bath, volume of solution, source of beetroot

© Revision Library | revisionlibrary.co.uk