S4 Biology Practice Paper: cell structure and microscope magnification, enzyme rates and Q10, competitive inhibition, diffusion, osmosis and water potential, photosynthesis and limiting factors, respiration and RQ, DNA base pairing, mitosis and meiosis, Mendelian genetics, energy flow and population estimates (100 marks)

Level: S4 | Subject: Biology | 75 minutes | 100 marks | 24 questions | question paper

Section A: Cells, Microscopes and Magnification (18 marks)

Answer all questions and show your working, units and significant figures.

#	Question	Marks
1	An eyepiece of x10 and an objective of x40 are used. A cell measures 8.0 mm on the photograph. (a) Find the total magnification. (b) Find the actual length of the cell in mm and in um. (c) If the field of view is 1.8 mm across, how many such cells fit across it?	5
2	State one main function of each of the following cell structures: (a) chloroplast (b) mitochondrion (c) ribosome (d) cell wall.	4
3	A light microscope has a resolution of 200 nm and an electron microscope 0.2 nm. (a) How many times better is the resolution of the electron microscope? (b) Can a ribosome 20 nm across be clearly resolved with a light microscope? Explain. (c) Why must specimens for the electron microscope be dead?	5
4	Two cube-shaped cells have sides of 10 um and 30 um. (a) Find the surface area to volume ratio of each in per um. (b) Find the ratio of the two values. (c) Why is exchange of substances more efficient in the smaller cell?	4

Section B: Enzymes and Metabolism (17 marks)

Answer all questions and show your working, units and significant figures.

#	Question	Marks
5	An experiment measures the gas released by an enzyme reaction: 0 min 0 cm3, 1 min 5.0 cm3, 2 min 14.0 cm3, 4 min 25.0 cm3. (a) Find the mean rate over the first 2 minutes. (b) Find the mean rate from 2 to 4 minutes and explain why it is lower. (c) How would you determine the maximum rate Vmax?	4
6	The rate of an enzyme reaction is 2.4 at 20 C, 4.8 at 30 C, 5.8 at 40 C and 0.2 cm3/min at 60 C. (a) Find Q10 from 20 C to 30 C. (b) Find Q10 from 30 C to 40 C. (c) Explain why the rate is almost zero at 60 C.	5
7	Pepsin has an optimum pH of about 2 and trypsin about 8. (a) Which one acts in the stomach? (b) Which one acts in the small intestine? (c) What happens to both at pH 4? (d) Why does extreme pH destroy an enzyme permanently?	4
8	A control reaction runs at 6.0 cm3/min and falls to 3.0 cm3/min after an inhibitor is added. (a) Find the percentage inhibition. (b) The rate returns to 5.8 cm3/min when much more substrate is added; which type of inhibition is this? Explain. (c) If the rate stayed at 3.0 cm3/min after adding substrate, which type would it be?	4

Section C: Diffusion, Osmosis and Water Potential (17 marks)

Answer all questions and show your working, units and significant figures.

#	Question	Marks
9	A plant cell has a solute potential of -800 kPa and a pressure potential of +300 kPa. (a) Find its water potential. (b) If the cell is placed in a solution of water potential -500 kPa, is there any net movement of water? (c) If it is placed in a solution of -300 kPa, in which direction does water move net? Explain.	4
10	Potato strips of initial mass 4.00 g are kept in sucrose solutions for 30 minutes: 0.0 M gives 4.36 g, 0.2 M gives 4.08 g and 0.4 M gives 3.60 g. (a) Find the percentage change in mass for each. (b) By interpolation between the 0.2 M and 0.4 M results, estimate the isotonic concentration at which there is no change in mass.	5
11	A dye diffuses 2.0 mm through agar in 30 minutes. Assuming the time taken is proportional to the square of the distance, find the time needed to diffuse 4.0 cm, in hours, and explain why diffusion alone cannot support large organisms.	4
12	(a) What happens to red blood cells placed in distilled water? Explain. (b) What happens in 0.9% sodium chloride solution? (c) Why is 0.9% sodium chloride, rather than pure water, used for intravenous infusion?	4

Section D: Photosynthesis and Respiration (16 marks)

Answer all questions and show your working, units and significant figures.

#	Question	Marks
13	Photosynthesis: 6CO2 + 6H2O -> C6H12O6 + 6O2 (Mr: CO2 = 44.0, O2 = 32.0, C6H12O6 = 180.0). (a) How many moles of CO2 are needed to make 1.8 g of glucose? (b) What mass of CO2 is that? (c) What mass of oxygen is released at the same time?	4
14	An aquatic plant releases oxygen bubbles per minute of 0 (dark), 3.0, 6.0, 6.0 and 6.2 at light intensities 0, 10, 20, 30 and 40 units. (a) At which light intensity is light saturation reached? (b) Which factor becomes limiting after saturation? (c) How would you show experimentally that this factor is carbon dioxide?	4
15	Yeast ferments glucose anaerobically: C6H12O6 -> 2C2H5OH + 2CO2 (Mr: glucose 180.0, ethanol 46.0; molar volume at room temperature 24.0 dm3/mol). (a) How many moles of CO2 come from 5.4 g of glucose? (b) What volume of CO2 is that at room temperature? (c) What mass of ethanol is formed?	4
16	An animal uses 200 cm3 of oxygen and releases 160 cm3 of carbon dioxide in one hour. (a) Find its respiratory quotient. (b) What does the RQ suggest about its diet? (c) Why is the RQ of fat lower than that of carbohydrate?	4

Section E: DNA, Genetics and Cell Division (16 marks)

Answer all questions and show your working, units and significant figures.

#	Question	Marks
17	A DNA molecule has 1000 bases in total, of which 300 are adenine. (a) Find the numbers of thymine, guanine and cytosine. (b) Find the percentage of adenine.	4
18	A human body cell has 46 chromosomes. (a) How many are in each daughter cell after mitosis? (b) How many are in a gamete after meiosis? (c) How many are in a zygote? (d) When is DNA replicated during mitosis?	4

19	Two pea plants of genotype Tt are crossed (T tall dominant, t dwarf recessive). (a) Give the genotype ratio of the offspring. (b) Give the phenotype ratio. (c) If there are 200 offspring, how many tall and how many dwarf plants are expected?	4
20	A recessive condition is caused by allele a. Two carriers (Aa x Aa) marry. (a) What is the probability that a child is affected? (b) What is the probability that two children are both affected? (c) Why does a carrier (Aa) not show the condition?	4

Section F: Ecosystems, Energy Flow and Populations (16 marks)

Answer all questions and show your working, units and significant figures.

#	Question	Marks
21	Producers in an ecosystem fix 50 000 kJ and only 10% of energy passes to each trophic level. (a) Find the energy available to primary, secondary and tertiary consumers. (b) What percentage of the producers energy reaches the top predator? (c) Why does energy decrease at each level?	4
22	In a 400 m2 meadow, 25 quadrats of 1 m2 are placed at random and 75 plants of a species are counted. (a) Find the density in plants per m2. (b) Estimate the total number of plants in the meadow. (c) Why must the quadrats be placed at random?	4
23	A capture-mark-recapture study of snails marks 40 individuals; a second catch of 50 contains 8 marked ones. (a) Estimate the population using the Lincoln index. (b) Give two factors that would make the estimate too high. (c) Why must marking not affect survival or the chance of being recaught?	4
24	(a) State the role of decomposers in the carbon cycle. (b) Why does the carbon dioxide level in the atmosphere stay roughly stable over long periods? (c) What effect does large-scale burning of fossil fuels have on the carbon cycle?	4