S4 Biology Practice Paper: Cells and Microscopy, Enzymes and Metabolism, Transport Across Membranes, Photosynthesis, Respiration and Gas Exchange, Biological Molecules and Food Tests (100 marks)

Level: S4 | Subject: Biology | 60 minutes | 100 marks | 24 questions | answer key

Section A: Cell Structure and Microscopy (17 marks)

Each question is worth 4-5 marks; show your working and units.

#	Question	Answer	Marks
1	A cell is viewed with a x10 eyepiece and a x40 objective; the image measures 20 mm. Find the total magnification and the actual length of the cell in um.	Total magnification = 10 x 40 = 400. Actual length = 20 mm / 400 = 0.05 mm = 50 um.	4
2	The field of view is 1.8 mm across at x100. What is its diameter in um at x400?	Magnification rises 4 times, so the diameter falls to one quarter: 1.8 mm / 4 = 0.45 mm = 450 um.	4
3	Two cube-shaped cells have sides of 20 um and 10 um. Calculate the surface area to volume ratio of each and state which diffuses more efficiently.	Side 20 um: area 2400 um2, volume 8000 um3, ratio 6/20 = 0.3 per um. Side 10 um: ratio 6/10 = 0.6 per um. The smaller cell diffuses more efficiently.	4
4	A light microscope resolves about 200 nm and an electron microscope about 0.2 nm. How many times better is the resolution, and what can the electron microscope show?	200 / 0.2 = 1000 times. It reveals organelles and fine detail such as mitochondrial cristae, ribosomes, rough endoplasmic reticulum, Golgi body and viruses.	5

Section B: Enzymes and Metabolism (17 marks)

Each question is worth 4-5 marks; include working and explanation.

#	Question	Answer	Marks
5	An enzyme catalyses at 2.4 units per minute at 27 C and 4.8 units per minute at 37 C. Calculate its Q10.	Q10 = rate at 37 C / rate at 27 C = 4.8 / 2.4 = 2.0, so the rate doubles per 10 C rise.	4
6	Enzyme activity is 100% at 30 C but only 20% at 50 C. Find the percentage drop and explain why high temperature inactivates the enzyme.	Activity falls by 100 - 20 = 80 percentage points. Heat breaks the hydrogen and ionic bonds holding the tertiary structure, so the active site changes shape and the enzyme is denatured.	4
7	Enzyme A has Km = 2.0 mM and enzyme B has Km = 0.5 mM. At 2.0 mM substrate, find v/Vmax for each and state which has the higher affinity.	v/Vmax = [S] / (Km + [S]); A: 2.0 / 4.0 = 0.50, B: 2.0 / 2.5 = 0.80. The lower Km means higher affinity, so B is 4 times higher.	4
8	Rate is 60 units per minute without an inhibitor and 24 with it. Find the percentage inhibition and name the type if raising substrate restores the rate.	Inhibition = (60 - 24) / 60 x 100% = 60%. The rate is restored by more substrate, so it is competitive inhibition: the inhibitor competes for the same active site.	5

Section C: Transport Across Membranes and Water Potential (17 marks)

Each question is worth 4-5 marks; mind the signs and units.

#	Question	Answer	Marks
9	A plant cell has solute potential -600 kPa and pressure potential 200 kPa. Find its water potential and say whether water moves if the external solution is at -400 kPa.	Water potential = -600 + 200 = -400 kPa. It equals the external value, so there is no net movement of water.	4
10	Potato strips go from 2.00 g to 2.40 g in distilled water and from 2.00 g to 1.60 g in 0.5 M sucrose. Calculate both percentage changes.	Water: (2.40 - 2.00) / 2.00 x 100% = +20% (water enters). Sucrose: (1.60 - 2.00) / 2.00 x 100% = -20% (water leaves, plasmolysis).	4
11	Diffusion time is proportional to the square of distance. If a leaf thins from 0.4 mm to 0.1 mm, how many times faster is diffusion?	Time ratio = (0.4 / 0.1)^2 = 16, so diffusion is 16 times faster.	4
12	Model a villus as a sphere of radius 0.1 mm. Find its surface area to volume ratio and the ratio at radius 0.2 mm, and relate this to absorption.	At r = 0.1 mm: area 0.126 mm2, volume 0.00419 mm3, ratio = 3 / r = 30 per mm; at r = 0.2 mm the ratio halves to 15 per mm. A larger ratio gives more absorbing surface per unit volume.	5

Section D: Photosynthesis (17 marks)

Each question is worth 4-5 marks; state mole ratios where needed.

#	Question	Answer	Marks
13	Photosynthesis: 6CO2 + 6H2O -> C6H12O6 + 6O2. If a leaf fixes 6 mol of CO2, what volume of oxygen is released at 24 dm3/mol?	The mole ratio of CO2 to O2 is 1:1, so 6 mol of O2 is released: 6 x 24 = 144 dm3.	4
14	Oxygen release is 12, 24 and 30 cm3/min at light intensities 20, 40 and 60 units. Find the percentage rise from 40 to 60 and identify the limiting factor.	Rise = (30 - 24) / 24 x 100% = 25%. Much smaller than the first rise (100%), so light is no longer limiting; CO2 concentration or temperature now limits the rate.	4
15	In chromatography the solvent front is 8.0 cm and a pigment band is 5.6 cm from the origin. Calculate its Rf and state its use.	Rf = 5.6 / 8.0 = 0.70. Under the same solvent and conditions Rf is constant, so it identifies pigments (chlorophyll b about 0.5, carotene about 0.95).	4
16	A 50 cm2 leaf releases 0.24 cm3 of oxygen per minute. Find the output per cm2 per minute and per hour, and explain why oxygen is used to measure the rate.	Per cm2 per minute = 0.24 / 50 = 0.0048 cm3; per hour = 0.0048 x 60 = 0.288 cm3. Oxygen is a direct product in a 1:1 mole ratio with CO2 fixed, so its output measures the rate.	5

Section E: Respiration and Gas Exchange (16 marks)

Each question is worth 4 marks; show the calculation steps.

#	Question	Answer	Marks

17	An organism takes in 200 cm3 of oxygen and releases 140 cm3 of CO2 in 10 minutes. Find the respiratory quotient and identify the main substrate.	RQ = 140 / 200 = 0.70. A value near 0.7 indicates fat as the main substrate (carbohydrate about 1.0, protein about 0.8).	4
18	Yeast ferments 0.180 g of glucose anaerobically. Find the theoretical volume of CO2 released (molar mass 180 g/mol, molar volume 24 dm3/mol).	Glucose = 0.180 / 180 = 0.001 mol; each mole gives 2 mol CO2, so 0.002 mol; volume = 0.002 x 24 = 0.048 dm3 = 48 cm3.	4
19	Complete oxidation yields 38 ATP per glucose and anaerobic glycolysis only 2. Find the fold difference and the aerobic efficiency given 30.5 kJ/mol ATP and 2870 kJ/mol glucose.	Fold = 38 / 2 = 19. Efficiency = (38 x 30.5) / 2870 x 100% = 1159 / 2870 = 40.4%.	4
20	At rest a person breathes 12 times per minute at 500 cm3 per breath; during exercise 30 times at 900 cm3. How many times greater is the minute ventilation?	Rest: 12 x 500 = 6000 cm3/min. Exercise: 30 x 900 = 27000 cm3/min. Ratio = 27000 / 6000 = 4.5.	4

Section F: Biological Molecules and Food Tests (16 marks)

Each question is worth 4 marks; include the test observations.

#	Question	Answer	Marks
21	A 5.0 g food sample contains 0.40 g of reducing sugar. Find the percentage by mass and describe a positive Benedict test.	Percentage = 0.40 / 5.0 x 100% = 8%. Positive: the blue solution turns green, yellow, orange or brick-red on heating as copper(I) oxide forms.	4
22	100 amino acids join into one polypeptide. Find the number of peptide bonds and water molecules removed, and name the reaction.	Peptide bonds = 100 - 1 = 99, and 99 water molecules are removed. The reaction is condensation, the reverse of hydrolysis.	4
23	One glycerol and three fatty acids form a triglyceride. Find the number of ester bonds and water molecules removed, and explain why lipids store energy well.	Three ester bonds and three water molecules. Lipids release about 38 kJ per gram (carbohydrate about 17 kJ) and are anhydrous and hydrophobic, so they store more energy per gram.	4
24	1.0 cm3 of 0.1% ascorbic acid just decolourises DCPIP; a fruit juice needs 2.5 cm3. Find the vitamin C concentration of the juice.	Concentration is inversely proportional to volume used: 0.1% x (1.0 / 2.5) = 0.04%.	4