S5 Biology Practice Paper: Genetics and Mutation, Energy Flow in Ecosystems, Gas Exchange and Transport, Osmosis and Water Potential, Enzymes and Metabolism

Level: S5 | Subject: Biology | 75 minutes | 100 marks | 24 questions | question paper

Section A Genetics and Mutation (18 marks)

Show genetic diagrams or working. Use correct genotype symbols and explain your reasoning.

#	Question	Marks
1	A tall pea plant (genotype Tt) is crossed with a dwarf plant (tt). (a) Use a genetic diagram to show the genotypes of the offspring. (b) Calculate the percentage of tall plants among the offspring.	4
2	Two gene pairs are on different chromosomes: AaBb x AaBb. (a) State the phenotypic ratio of the offspring. (b) Calculate the percentage of double recessives (aabb). (c) Explain why the two gene pairs assort independently.	5
3	One base in the beta-globin gene changes from A to T, so the sixth amino acid changes from glutamine (codon GAG) to valine (codon GUG). (a) Name this type of mutation. (b) Explain why a single base change can affect protein function. (c) Contrast the effect of inserting two bases instead.	4
4	Red-green colour blindness is X-linked recessive, written X^c. A carrier mother (X^c X) marries a normal father (X Y). (a) What is the chance that a son is colour blind? (b) What is the chance that a daughter is a carrier? (c) What is the chance that any child is colour blind?	5

Section B Energy Flow in Ecosystems (17 marks)

Show the formula and units in every calculation. Give answers to three significant figures.

#	Question	Marks
5	Producers in a grassland fix 50,000 kJ per square metre per year, and the energy transfer efficiency between trophic levels is 10%. (a) Calculate the energy available to primary consumers. (b) Calculate the energy available to tertiary consumers. (c) Calculate the overall transfer efficiency from producers to tertiary consumers.	5
6	A forest ecosystem has a gross primary productivity of 4,800 kJ per square metre per year, and producers respire 2,300 kJ per square metre per year. (a) Calculate the net primary productivity. (b) Explain what NPP means for the ecosystem. (c) State where the remaining energy goes.	4
7	Consider the food chain: grass -> grasshopper -> frog -> snake -> hawk. (a) State the trophic level of the hawk. (b) Give three reasons why so much energy is lost between adjacent trophic levels. (c) Explain why food chains rarely exceed four or five trophic levels.	4
8	A hectare of forest holds 12,000 kg of dry biomass, which is 45% carbon by dry mass. (a) Calculate the mass of carbon stored. (b) If decomposers break it all down completely, calculate the mass of carbon dioxide released. (c) State the role of decomposers in the carbon cycle.	4

Section C Gas Exchange and Transport (17 marks)

Show working with units. In explanation questions name the structures involved.

#	Question	Marks

9	A student breathes in 500 cm3 of air per breath, 12 times per minute, and uses 250 cm3 of oxygen per minute. (a) Calculate the ventilation rate per minute. (b) Calculate the percentage of oxygen extracted from the inhaled air. (c) Explain why the extraction percentage rises during exercise.	5
10	Haemoglobin is 98% saturated in lung capillaries and 75% saturated in muscle capillaries during exercise. (a) Calculate the percentage of oxygen released per unit of haemoglobin in the tissue. (b) Explain how the Bohr effect assists this. (c) Explain the advantage of the fetal haemoglobin curve lying to the left.	4
11	A leaf has an area of 25 cm2 and a lower-epidermis stomatal density of 200 per square millimetre. (a) Calculate the total number of stomata on the leaf. (b) Explain the mechanism that opens stomata by day and closes them at night. (c) State the effect of stomatal closure on water loss.	4
12	A person has a stroke volume of 70 cm3 and a resting heart rate of 72 beats per minute. (a) Calculate the resting cardiac output. (b) During exercise the heart rate rises to 150 per minute; assuming stroke volume is unchanged, calculate the cardiac output and the percentage increase. (c) State the benefit of the higher cardiac output to muscles.	4

Section D Osmosis and Water Potential (16 marks)

Water potential is measured in kPa. Show the formula and give units in every answer.

#	Question	Marks
13	A plant cell has a solute potential of -800 kPa and a pressure potential (turgor) of 400 kPa. The surrounding solution has a water potential of -600 kPa. (a) Calculate the water potential of the cell. (b) State and explain the net direction of water movement. (c) Predict how the cell changes after some time.	4
14	A 0.10 mol dm-3 sodium chloride solution is prepared at 25 degrees Celsius. R = 8.31 J mol-1 K-1 and NaCl is fully ionised (i = 2). (a) Calculate the solute potential of the solution. (b) Explain why i equals 2 for NaCl. (c) Compare it with a glucose solution of the same concentration.	5
15	Four potato strips of the same batch each start at 2.40 g. After one hour, strip A weighs 2.70 g and strip B weighs 2.10 g. (a) Calculate the percentage change in mass for each strip. (b) Decide which strip was in pure water and which in concentrated sugar solution, and explain. (c) State how the experiment could be made more reliable.	4
16	A plant transpires 24 cm3 of water in two hours. (a) Calculate the mean transpiration rate in cm3 per hour and per minute. (b) Explain how the transpiration pull moves water from root to leaf.	3

Section E Enzymes and Metabolism (16 marks)

Show working. In explanation questions refer to the active site or enzyme-substrate complex.

#	Question	Marks
17	An enzyme works at 8 units per minute at 20 degrees Celsius and 16 units per minute at 30 degrees Celsius. (a) Calculate the temperature coefficient Q10. (b) Predict the rate at 45 degrees Celsius and explain. (c) Distinguish Q10 from denaturation.	4
18	An enzyme is studied with two inhibitors. Without inhibitor Vmax = 120 and Km = 4 mmol dm-3; with inhibitor X, Vmax = 120 and Km = 8; with inhibitor Y, Vmax = 60 and Km = 4. (a) Identify the type of inhibition for X and for Y. (b) Explain how X works. (c) State how the inhibition by X can be relieved experimentally.	4

19	Initial rates of an enzyme at different substrate concentrations are: at 2 mmol dm-3 the rate is 40; at 4 it is 60; at 8 it is 80; and at saturation the rate is 120 units. (a) Find Vmax and Km. (b) Explain the biological meaning of Km. (c) Explain why the rate eventually levels off.	5
20	Complete oxidation of 1 mol of glucose releases 2,870 kJ. The cell produces 38 mol ATP, and each mole of ATP stores 30.5 kJ. (a) Calculate the energy stored in ATP. (b) Calculate the efficiency of respiration. (c) State where the remaining energy goes.	3

Section F Integrated Data Analysis (16 marks)

Show the formula, substitute values and interpret. For the statistical test state the degrees of freedom.

#	Question	Marks
21	Two heterozygous tall pea plants are crossed. Of 400 offspring, 310 are tall and 90 are dwarf. A 3 : 1 ratio predicts 300 and 100. (a) Calculate chi-square. (b) State the degrees of freedom. (c) Decide whether the 3 : 1 hypothesis is supported (critical value 3.84).	5
22	A grassland food chain is grass -> rabbit -> snake -> hawk, with 10% energy transfer efficiency. The hawk population needs 5 kg of biomass. (a) Calculate the biomass of snakes, rabbits and grass required. (b) Explain why top predators are usually few in number. (c) State the effect on the grass if people hunt snakes heavily.	4
23	The rate of gas diffusion is proportional to surface area and concentration difference, and inversely proportional to diffusion distance. If a respiratory surface doubles its area and halves its thickness, with the same concentration difference: (a) calculate the factor by which the diffusion rate changes. (b) Apply this to the structure of alveoli. (c) Explain how smoking disrupts this relationship.	4
24	The water potential of a guard cell falls from -300 kPa to -700 kPa. (a) Calculate the increase in turgor pressure available. (b) Explain how this opens the stoma. (c) Explain how a plant protects itself in drought.	3