S5 Biology Practice Paper: Cell Cycle and Mitosis, Enzyme Kinetics and Inhibitors, Photosynthesis and Respiration Energetics, Mendelian and Sex-Linked Inheritance, Population Growth and Mark-Recapture, Community Diversity, Vaccines and Herd Immunity (100 marks)

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

Part 1 Cell Cycle, Mitosis and Cell Differentiation (16 marks)

Show all formulae, substitutions and units; give percentages to 1 d.p.

#	Question	Marks
1	A somatic cell cycle of an animal lasts G1 10 hours, S 8 hours, G2 4 hours and M 2 hours. (a) Find the length of one complete cycle; (b) calculate the percentage of the cycle spent in M phase (1 d.p.); (c) state the main event that occurs during S phase.	4
2	Of 200 dividing cells observed under a microscope, 16 are in M phase, which is estimated to last 2 hours. (a) Find the proportion of cells in M phase; (b) hence estimate the length of the whole cell cycle; (c) explain why this method may over- or under-estimate the cycle length.	4
3	A human somatic cell has 46 chromosomes and has just completed S phase. (a) How many chromosomes does it now contain? (b) How many sister chromatids? (c) After centromeres split in anaphase, how many chromosomes are temporarily in the cell? (d) How many chromosomes does each daughter cell receive?	4
4	(a) Compare mitosis and meiosis in terms of the number of daughter cells and their chromosome number; (b) explain why skin stem cells can keep replacing epidermal cells while most neurons cannot; (c) state one consequence of uncontrolled mitosis.	4

Part 2 Enzyme Kinetics, Michaelis-Menten Equation and Inhibitors (18 marks)

Express rates in μmol min^{-1} or μmol min^{-1} mg^{-1} and always state the unit.

#	Question	Marks
5	An enzyme reaction produces 45 μmol of product in 30 minutes. (a) Calculate the mean rate in μmol min^{-1}; (b) in another run 90 μmol is produced in 60 minutes — is the rate the same? Explain.	5
6	The activity of an enzyme (relative units) at pH 5, 6, 7 and 8 is 22, 48, 35 and 9 respectively. (a) State the optimum pH; (b) calculate how many times greater the activity at pH 6 is than at pH 8 (1 d.p.); (c) explain why activity falls away from the optimum.	5
7	An enzyme has Vmax = 40 μmol min^{-1} and Km = 2 mM. (a) Use the Michaelis-Menten equation to find the rate when substrate concentration is 6 mM; (b) what is the rate when substrate concentration equals Km? (c) explain the biological meaning of Km.	4
8	Compare competitive and non-competitive inhibition. At the same substrate concentration of 6 mM, Vmax = 40 μmol min^{-1} and Km = 2 mM, a competitive inhibitor raises the apparent Km to 6.0 mM (Vmax unchanged), while a non-competitive inhibitor lowers Vmax to 20.0 μmol min^{-1} (Km unchanged). (a) Calculate the rate in each inhibited case at that substrate concentration; (b) explain why a high substrate concentration overcomes competitive inhibition.	4

Part 3 Photosynthesis, Respiration and Energy Efficiency (16 marks)

Express energy in kJ to 1 d.p.; all equations must be balanced.

#	Question	Marks
9	The overall equation for photosynthesis is 6CO2 + 6H2O -> C6H12O6 + 6O2. A leaf synthesises 0.5 mol of glucose. (a) How many moles of CO2 are needed? (b) What mass is that? (c) How many moles of O2 are released?	4
10	An aquatic plant releases 0, 12, 28, 40 and 41 oxygen bubbles per minute at 0, 2, 4, 6 and 8 klx. (a) Describe how oxygen release changes with light intensity; (b) estimate the light saturation point; (c) explain why a few bubbles may still appear at 0 klx; (d) predict the effect of using 0.1% sodium hydrogencarbonate solution.	4
11	Complete aerobic oxidation of 1 mol glucose releases 2870 kJ and yields 38 ATP; each mole of ATP stores 30.5 kJ. (a) Calculate the energy stored in ATP; (b) find the efficiency of energy transfer (1 d.p.); (c) state where the remaining energy goes.	4
12	In oxygen shortage muscle carries out lactic acid fermentation, yielding only 2 ATP per mole of glucose. (a) Calculate its energy efficiency (1 d.p.); (b) how many times more efficient is aerobic respiration (1 d.p.); (c) explain why muscles still ache and breathing stays rapid after vigorous exercise.	4

Part 4 Mendelian Inheritance, Sex Linkage and Blood Group Probability (18 marks)

Give probabilities as both a fraction and a percentage; use standard genetic symbols.

#	Question	Marks
13	Two heterozygous black mice (Aa x Aa) are crossed, black being dominant. (a) State the gametes produced; (b) use a Punnett square to find the genotype ratio; (c) give the phenotype ratio; (d) if 200 offspring are produced, about how many are expected to be black?	5
14	In peas A/a controls seed shape and B/b seed colour, on different chromosomes. A test cross AaBb x aabb yields 160 seeds. (a) List the four gamete types; (b) give the phenotype ratio; (c) how many seeds of each phenotype are expected? (d) What would happen if the two gene pairs were on the same chromosome?	5
15	Colour blindness is X-linked recessive. A carrier mother (X^C X) marries a normal father (X Y). (a) Give the possible offspring genotypes and their ratio; (b) the probability that a son is colour-blind; (c) the probability that a daughter is colour-blind; (d) why are affected males far more common than affected females?	4
16	The parents are blood group A (I^A i) and B (I^B i). (a) Give the possible blood groups of the children and their ratio; (b) the probability that both of two children are group O; (c) if they have 4 children, how many are expected to be group AB? (d) explain why group O parents cannot have a group AB child.	4

Part 5 Population Growth, Mark-Recapture and Community Diversity (16 marks)

State the formula used for each population estimate; round indices to whole numbers.

#	Question	Marks
17	Producers in a grassland fix 20,000 kJ m-2 yr-1 and only 10% of the energy passes to the next trophic level. (a) Find the energy available to primary, secondary and tertiary consumers; (b) explain where the other 90% goes; (c) why do food chains rarely exceed 4-5 levels?	4
18	A population starts the year with 100 individuals; during the year 20 are born, 8 die, 4 immigrate and 2 emigrate. (a) Find the net change; (b) the growth rate (%); (c) the population at year end; (d) what long-term growth pattern is expected if resources are fixed?	4

19	Mark-recapture is used to estimate a snail population: 80 snails are caught, marked and released, and after mixing 100 are recaught of which 8 are marked. (a) Estimate the population size; (b) give two factors that make the estimate too high; (c) why must marking not affect survival or movement?	4
20	Community A has species proportions 0.25, 0.25, 0.25 and 0.25; community B has 0.7, 0.1, 0.1 and 0.1. (a) Calculate the Simpson index D = 1 - sum(p squared) for both (2 d.p.); (b) which is more diverse? (c) What happens to diversity if the dominant species disappears from B?	4

Part 6 Immunity, Vaccines, Herd Immunity and Disease Surveillance (16 marks)

Express all rates per 100 000 population to 1 d.p.

#	Question	Marks
21	A disease has a basic reproduction number R0 = 4. (a) Calculate the vaccination coverage needed for herd immunity (%); (b) in a population of {pop:,}, how many people must be vaccinated? (c) explain why the coverage actually required is usually higher than the theoretical value.	4
22	After two exposures to the same antigen, antibody concentration rises within 3 days of the second exposure to five times the first peak, which took about 14 days. (a) Name the two responses; (b) explain why the second is faster and stronger; (c) how do vaccines exploit this? (d) name one immune mechanism that kills pathogens without antibodies.	4
23	A city of 50,000 people records 150 new cases in one year. (a) Calculate the incidence per 100 000 population (1 d.p.); (b) if the population rises to {int(popn*1.2):,} next year at the same incidence, predict the number of new cases; (c) distinguish incidence from prevalence.	4
24	(a) Explain why antibiotics do not work on viruses but do on bacteria; (b) explain how misuse of antibiotics leads to resistance; (c) give two public health measures that limit the spread of resistance; (d) why is it important to finish the whole course?	4