S6 Biology Practice Paper: Mendelian Genetics and Probability, DNA Structure and Semi-conservative Replication, Transcription and Translation, Gene Mutation and Genetic Disorders, Hardy-Weinberg Equilibrium, Recombinant DNA and PCR, Ecosystem Energy Flow and Carbon Cycle, Population Dynamics and Biodiversity (100 marks)

Level: S6 | Subject: Biology | 75 minutes | 100 marks | 24 questions | question paper

Section A: Mendelian Genetics and Probability (17 marks)

Each question is worth 4-5 marks; show the gametes and ratios.

#	Question	Marks
1	In peas, seed shape (R round > r wrinkled) and cotyledon colour (Y yellow > y green) are inherited independently. Two RrYy plants are crossed and produce 240 seeds. Work out the expected number of each of the four phenotypes (round-yellow, round-green, wrinkled-yellow, wrinkled-green).	4
2	The 240 seeds are classified as round-yellow 140, round-green 42, wrinkled-yellow 44, wrinkled-green 14. Use the chi-square test, chi-square = sum of (O-E)^2/E, and decide whether the 9:3:3:1 ratio is rejected (critical value 7.82 at df = 3, p = 0.05).	4
3	An RrYy plant is test-crossed with a homozygous recessive rryy plant, giving 160 offspring. Give the expected number and the ratio of the four phenotypes.	4
4	Human ABO blood groups are controlled by three alleles IA, IB and i. The parents are IAi (group A) and IBi (group B). (a) List the possible genotypes, blood groups and probabilities of their children. (b) If they have four children, what is the probability that all four are group O?	5

Section B: DNA Structure, Replication and Protein Synthesis (17 marks)

Each question is worth 4-5 marks; show your working for base and hydrogen-bond numbers.

#	Question	Marks
5	A double-stranded DNA molecule is 1200 base pairs long and adenine (A) makes up 30% of all bases. Find the numbers of A, T, G and C, and the total number of hydrogen bonds in the molecule (2 between A and T, 3 between G and C).	4
6	A polypeptide contains 250 amino acids. (a) What is the minimum number of bases in the mRNA that codes for it, including the stop codon? (b) What is the minimum number of bases in the template strand of the corresponding DNA?	4
7	DNA replicates semi-conservatively. One DNA molecule replicates 3 times in succession. Find (a) the total number of DNA molecules produced, (b) the number of molecules containing a parental (original) strand, and (c) the total number of newly synthesised strands.	4
8	Describe the three main stages of DNA replication, explain why an RNA primer is needed, and state one experiment that demonstrates that replication is semi-conservative.	5

Section C: Mutation, Genetic Disorders and Hardy-Weinberg Equilibrium (17 marks)

Each question is worth 4-5 marks; express allele frequencies as q and p.

#	Question	Marks
9	A recessive disorder affects 1 in 10,000 people in a population at Hardy-Weinberg equilibrium. Find the recessive allele frequency q, the dominant allele frequency p and the carrier (heterozygote) frequency.	4
10	In a population of 1000 people, 40 are affected by a recessive disorder. Assuming Hardy-Weinberg equilibrium, find q, p and the number of carriers.	4
11	A disorder is inherited as an X-linked recessive trait. The mother is a carrier (X^A X^a) and the father is normal (X^A Y). Find (a) the probability that a son is affected, (b) the probability that a daughter is affected, and (c) the overall probability that a child is affected.	4
12	(a) Explain why X-linked recessive disorders are usually more common in males than in females. (b) Using q = 0.01, compare the number of carriers with the number of affected individuals and hence explain why consanguineous marriage increases the risk of recessive disorders.	5

Section D: Recombinant DNA, PCR and Biotechnology (17 marks)

Each question is worth 4-5 marks; name the enzymes and the steps used.

#	Question	Marks
13	A plasmid is 4000 bp long. A 800 bp human cDNA is inserted to form a recombinant plasmid. Find the size of the recombinant plasmid and explain how gel electrophoresis can distinguish recombinant from non-recombinant plasmids.	4
14	The polymerase chain reaction (PCR) starts from a single DNA template molecule and runs for 30 cycles. Find the number of DNA molecules after amplification.	4
15	E. coli divides every 0.5 hour at a suitable temperature. Starting from one cell, the culture is grown for 4 hours. Find (a) the number of cells and (b) the total number of insulin molecules if each cell produces 5000 molecules.	4
16	Describe the four main steps in producing human insulin using bacteria, and explain why cDNA rather than human genomic DNA must be used.	5

Section E: Ecosystem Energy Flow and the Carbon Cycle (16 marks)

Each question is worth 4 marks; give energy in kJ per square metre per year.

#	Question	Marks
17	Producers in an ecosystem fix 250000 kJ per square metre per year. If the transfer efficiency between successive trophic levels is 10%, find the energy available per square metre per year to the primary, secondary and tertiary consumers.	4
18	An ecosystem absorbs 20000 kJ of light energy per year. Gross primary production (GPP) is 2000 kJ and producers respire 1200 kJ. Find (a) the photosynthetic efficiency and (b) the net primary production (NPP).	4
19	If a tertiary consumer needs 50 kJ of energy per year and the transfer efficiency is 10%, what is the minimum energy the producers must fix? Explain what happens to the rest of the energy.	4
20	Explain the roles of photosynthesis, respiration, decomposition and the burning of fossil fuels in the carbon cycle, and use energy flow to explain why food chains usually have only 4 to 5 trophic levels.	4

Section F: Population Dynamics and Biodiversity (16 marks)

Each question is worth 4 marks; state the formula and assumptions.

#	Question	Marks
21	A mark-recapture study is used to estimate population size: 40 snails are caught, marked and released; a week later 36 snails are caught, of which 12 are marked. Estimate the population size using the Lincoln index N = (M x C)/R.	4
22	A quadrat survey is made of grassland plants: 50 quadrats of 0.5 square metres each are placed at random and contain on average 4.2 plants of the target species. Find (a) the population density (plants per square metre) and (b) the estimated total in a grassland of 2000 square metres.	4
23	A population grows from 1200 to 1560 individuals in one year with no immigration or emigration. Find (a) the percentage growth rate, (b) the per capita growth rate r, and (c) the doubling time from t = ln2/r (2 decimal places).	4
24	(a) List the three levels of biodiversity with one example each. (b) Give two reasons why an ecosystem with higher biodiversity is more resistant to environmental change.	4